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VOLUME LII.

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PREFACE.

THE first Review of the Mineral Production of India published by the Geological Survey, appeared as Part I of Volume XXXII of these Records. In preparing it, the Director, Sir Thomas Holland, designed the general plan of the work, and surveyed the progress made during the preceding six years 1898-1903. The next issue, covering the quinquennial period 1904-08, prepared by Sir Thomas Holland and Dr. Fermor, followed the same general plan, but was purposely made more descriptive, in order that it might take the place of the Manual on Economic Geology which had long been out of print. Any manual of the kind must necessarily include considerable references to the statistics on mineral production, and, consequently, would, by its nature, rapidly become out of date. It was, accordingly, decided to expand the Quinquennial Review and to draw attention to the principal mineral occurrences known to the Geological Survey, leaving further development of detail for memoirs on special minerals or groups of minerals, as has been done in the case of mica, coal and manganese. The second Quinquennial Review was, accordingly, expanded, and experience having shown it to be of real use to the general public, the third issue was brought up to date by Dr. Fermor and myself on the same lines.

2. In the preparation of the present review, which is the fourth of the series, several other officers of the Geological Survey have collaborated by revising the sections dealing with some of the minerals; the name of the officer who is responsible for the revision of each section is shown in the text. But the general plan has been retained, and in many cases the descriptive part has also remained practically as originally written, the only change in such cases being that recent additions to our information have been inserted and figures and statistics brought up to date.

H. H. HAYDEN.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

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QUINQUENNIAL REVIEW OF THE MINERAL PRODUCTION OF INDIA FOR THE YEARS 1914 TO 1918. *By the Director and Senior Officers of the Geological Survey of India.*

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I.—INTRODUCTION.

[H. H. HAYDEN.]

In the first Review it was explained that although many valuable mineral products were being worked in different parts of the country it was impossible to obtain figures about some of them sufficiently precise to be of any value for statistical purposes. The most conspicuous of these 'minerals' are the various forms of building material and slate, which are naturally used extensively in every district and would form an excellent index of material progress if we could rely on the figures returned, and could regard those of one period as fairly comparable with those of another.

Grouping of the minerals.

In order to obtain some mental impression of progress, we are compelled to exclude from the list of minerals, contributing to the statement of total values those about which we can obtain only partial figures or rough local estimates. The minerals are thus reviewed in two groups as before, namely—

Group I.—Those for which approximately trustworthy annual returns are obtainable; and

Group II.—Those regarding which regularly recurring and full particulars cannot be procured.

As the methods of collecting the returns become more precise from year to year and the machinery employed for the purpose becomes more efficient, the minerals included in Group I tend to increase in number; that group now comprises:

Chromite.	Manganese.
Coal.	Mica.
Copper.	Monazite.
Diamonds.	Petroleum.
Gold.	Ruby, Sapphire and Spinel.
Graphite.	Salt.
Iron.	Saltpetre.
Jadeite.	Silver.
Lead.	Tin.
Magnesite.	Tungsten.

Units recognised.

Unless otherwise stated, the ton referred to in this Review is the English statute ton of 2,240 lbs. Where there are totals likely to be of interest to foreign readers weights are also expressed in metric tons of 1,000 kilogrammes each (equal to 0·984 statute ton). Returns in maunds have been translated into tons, cwts, and qrs. throughout. The output of petroleum has been given in Imperial gallons and totals are expressed also in metric tons assumed to be equivalent to 249 gallons of crude oil of an average specific gravity of 0·885. Values are given in sterling calculated throughout at the rate of Rs. 15=£1, which was the fixed rate of exchange throughout practically the whole period.

Sources of information.

The data employed in this Review have been obtained from various sources. Before the year 1904 the Annual Statistics of Mineral Production were published by the Director-General of Statistics. Since then the figures of mineral production for India have been published annually in the Records of the Geological Survey of India. Returns of mineral production are now sent by Local Governments and Political Agents direct to the Geological Survey office, except in the case of mines under the Mines Act, when the figures are forwarded direct by mine-managers to the Chief Inspector of Mines, who forwards a summary to the Geological Survey. Information regarding exports and imports has been taken from the publications issued by the Director of Statistics. Additional information has been obtained from the following sources :—

(1) Annual Returns of the Chief Inspector of Mines in India and the Chief Inspector of Mines for Mysore ;

(2) Returns and Annual Reports of the Gold Mining Companies of the Kolar, Dharwar and Hutti Fields, kindly supplied by the Managing Agents ;

(3) Annual Administration Reports of the various Local Governments and Local Administrations in India ;

(4) Annual Administration Reports of the Railway Board ;

(5) Returns issued by the various Geological Surveys, and Statistics relating to Mines and Quarries, published by the English Home Office.

We are also indebted to the Managing Agents of several Mining Companies for much information supplied direct.

II.—SUMMARY OF PROGRESS.

[H. H. HAYDEN.]

Total values.

The following table summarises the output and value of the principal minerals produced during the five years under review. The total values have the obvious defect of being due to the addition of unlike denominations; for export values, being the only returns obtainable in some cases, are ranged with spot values, while the latter necessarily vary with the position of the mine, representing not the *values* but the *prices* obtainable. In the case of coal, for instance, the so-called value of a ton of good coal in Bengal is less than half that of the inferior material raised in Baluchistan; in the case of salt the values given are the prices charged, and are less than the duty, which is the principal value of the salt to Government; certain valuable mineral products, such as building stones, are omitted altogether, for want of any but very approximate estimates.

The values returned for minerals exported are also necessarily lower than they would be if those minerals were consumed in the country and it is consequently unfair to compare this table of values with corresponding returns for countries in which metallurgical industries flourish. Manganese-ore is a conspicuous example of a product the value of which, to the Indian producer, is reduced by the heavy cost of transport. The country is thus not only so much poorer by the loss of the metal exported in the ore, but is paid in return little more than half its market value.

Comparison with the previous periods.

The imperfections of the table are those confessedly inseparable from all such estimates of mineral production; and it is of use merely as a means of comparing one year with another, the same system being carried through the whole period under review. In the present case also the value of comparison with other quinquennial periods is largely discounted by the fact that the period under review is almost entirely covered by the war, when conditions were abnormal. The output of certain minerals was stimulated, while that of others was restricted: wolfram is a case in point. Again, manganese, for which there was a strong market before the war, was seriously affected by the absence, or the high rate, of freight, and only

certain grades were saleable; mines producing only low-grade ores were therefore closed. These and other abnormal conditions have led in some cases to greatly reduced output; on the other hand, a remarkable rise in price often masks this effect, and the figures given in table 1 are comparable only among themselves—strictly only for the years 1915-18—and comparison with pre-war figures is likely to be misleading in individual cases. But the general trend of the Indian mineral industries is fairly clear and the advance made during the five years under review is very remarkable, the value of the total output having more than doubled itself in the last ten years, rising from £7,600,000 in 1909 to nearly £15,000,000 in 1918, exchange being calculated at 1*s.* 4*d.* in both cases.

The increase during the whole quinquennial period amounts to over £5,000,000, as against a little over £2,000,000 in the preceding quinquennium.

The most remarkable increases occurred in the case of coal, manganese, salt, tin, chromite, saltpetre, tungsten and silver; in every case the effect is magnified by inflated prices. The general rise in price of all ordinary commodities acted prejudicially on the gold output, certain mines being compelled to close down. This is the only mineral which shows a decline of any importance during the period under review.

Metallurgical industries.

The stimulating effect of the war on metallurgical industries was equally remarkable. Certain materials hitherto obtained from abroad could no longer be imported, and the only means of obtaining them was by manufacture in this country. The activities and output of the Tata Iron and Steel Works at Jamshedpur were greatly increased, as also were those of the Bengal Iron and Steel Company at Kulti. The operations of the Burma Corporation at Bawdwin were also extended; and the output of lead and silver largely increased. Negotiations are on foot for the establishment in India of works to treat the zinc concentrates from the same mine with the production of sulphuric acid as a by-product. It is to be hoped that this will yield a reasonably cheap supply of acid, for the want of which it has hitherto been impossible to develope chemical industries on a large scale. Copper-smelting was inaugurated at the Rakha Mines during the period under review, but operations only began towards the end of 1918.

TABLE 1.—*Output and Value of Minerals for which Returns of Production are available for the years 1914 to 1918.*

Mineral.		1914.	1915.	1916.	1917.	1918.	*Average.*
Coal	£	3,907,380	3,781,064	3,878,564	4,511,645	6,017,215	*4,419,174*
	tons.	16,464,263	17,103,932	17,254,309	18,212,918	20,722,493	*17,951,583*
Gold	£	2,338,355	2,369,846	2,303,023	2,221,889	2,060,152	*2,258,653*
	oz.	607,388·07	616,728·24	598,369·69	574,293·01	536,118·32	*586,579·47*
Petroleum	£	958,565	1,065,182	1,119,405	1,092,965	1,131,904	*1,073,604*
	Gallons	259,342,710	287,093,576	297,189,787	282,759,523	286,585,011	*282,594,121*
Manganese-ore (*a*)	£	775,220	867,010	1,372,248	1,238,605	1,008,932	*1,052,403*
	tons.	603,754	420,063	595,594	487,448	352,650	*491,902*
Salt (*b*)	£	483,289	660,254	728,358	996,020	1,645,195	*902,623*
	tons.	1,848,225	1,745,521·7	1,488,570·4	1,427,599·6	1,856,696·7	*1,573,323*
Saltpetre	£	272,462	374,035	607,579	527,731	589,190	*474,188*
	tons.	15,545·6	18,117	25,057·5	21,288·9	24,740·8	*20,949·2*
Tungsten-ore	£	175,150	286,190	497,397	623,074	726,681	*461,698*
	tons.	2,243·6	2,456·8	3,692·5	4,542	4,431·2	*3,473·2*
Mica (*c*)	£	237,810	183,947	311,680	508,173	625,741	*373,370*
	cwt.	40,502	30,390	54,705	62,434	60,075	*49,621*
Lead-ore and Lead	£	202,330	316,182	428,383	397,478	450,477	*358,970*
	tons.	10,563·2	13,557	13,989·5	17,109	19,115	*14,857·7*
Silver	£	26,896	31,150	88,687	237,216	295,696	*135,929*
	oz.	236,446	285,387	760,374	1,581,838	1,971,783	*967,166*
Jadestone (*e*)	£	67,052	46,380	81,659	85,944	91,456	*74,498*
	cwt.	4,971	5,202	6,136	3,609	3,336	*4,651*
Tin-ore and Tin	£	34,957	43,333	59,104	94,495	134,635	*73,376*
	cwt.	6,239	8,339·9	11,570·2	16,138·9	17,621	*11,981·7*
Monazite	£	41,411	32,238	37,714	56,489	58,819	*45,334*
	tons.	1,185·6	1,107·7	1,292·3	1,940·3	2,117·2	*1,528·6*
Ruby, Sapphire and Spinel.	£	43,133	36,298	37,513	51,831	40,310	*41,817*
	carats	304,872	251,449	209,724	198,200	164,115	*225,672*
Iron-ore	£	36,316	29,010	34,099	33,576	41,105	*34,819*
	tons.	441,574·3	390,338·8	411,808·8	413,356·5	492,669·1	*429,949·5*
Chromite	£	2,611	3,531	16,401	26,215	52,063	*20,164*
	tons.	5,888	3,767	20,159	27,061·4	57,769·5	*22,929*
Copper-ore	£	7,294	14,381	6,202	30,162	4,053	*12,418*
	tons.	5,324·02	8,885	4,135	20,108	3,619	*8,414*
Magnesite	£	557	3,973	14,112	14,559	4,641	*7,568*
	tons.	1,680	7,450	17,640	18,202	5,853	*10,165*
Diamond	£	791	608	361	1,700	2,625	*1,216*
	carats	54·65	35·99	20·42	28·52	73·29	*42·57*
Graphite (*d*)	£	..	158	1,501	547	361	*641*
	tons.	..	71	1,318·4	102·7	81	*393·3*
Amber	£	274	199	157	684	87	*280*
	cwt.	13	11·5	5·5	59·1	2·9	*18·4*
TOTAL value	£	9,611,353	10,144,964	11,624,147	12,750,998	14,981,338	11,822,748

(*a*) Export values of quantities actually exported.
(*b*) Prices without duty.
(*c*) Export figures.
(*d*) Average for 4 years.
(*e*) Figures represent overland trade and exports *viâ* Rangoon combined.

Comparison with foreign mineral production.

In previous Reviews, figures showing the values of the leading mineral products of the United Kingdom, the United States and Germany have been quoted for comparison with those of India. Figures for the United States and Germany are no longer available, but table 2 shows the values of the more important mineral products of the United Kingdom during the year 1918. The enormous preponderance of the coal industry in the United Kingdom is remarkable, while the next most important mineral product in the world (iron-ore) takes the second place. It is satisfactory to note that the Indian coal trade has made enormous strides during the last five years, and although the present output of iron-ore is comparatively small, it will undoubtedly rise in the near future, while recent discoveries in Singhbhum and other parts of Bihar and Orissa indicate that India possesses reserves of iron-ore which will compare in quality and quantity with those of almost any other country in the world.

TABLE 2.—*Values (a) during 1918 of the Twelve Leading Mineral Products in the United Kingdom.*

	£
Coal	238,240,760
Iron-ore	7,106,656
Stone (*b*)	3,747,269
Clay and Shale	1,696,127
Salt	1,647,997
Oil Shale	1,528,584
Tin-ore (dressed)	1,115,926
Slate	429,583
Gravel and Sand	291,627
Lead-ore	273,462
Barium (compounds)	218,592
Arsenic	210,101

(*a*) Value at mine or quarry.
(*b*) Including Limestone, Sandstone and Igneous Rocks.

Imports of minerals and mineral products.

In this place, also, it will be interesting to note the values recorded for imported minerals and for products obtained directly from minerals, during the period under review. These figures, ex-

clusive of the values of cutlery and hardware, machinery and millwork, railway plant and rolling stock, earthenware and porcelain, glass and glassware, jewellery and plate of gold and silver, paints and colours, and alizarine and aniline dyes, are shown in table 3. This table is instructive as showing the effects of the war on imports. The figures for 1914 may be regarded as approximately normal, since the war did not begin to take effect till near the end of the year, but even in that year there was a considerable decrease as compared with the figures for 1913. During the next year the decline was still more remarkable, and although there were slight apparent recoveries in subsequent years, these are probably due to rise in price rather than to increased imports. Table 4 is even more instructive; the remarkable fall in the value of the imports of railway material from nearly £10,000,000, in 1914 to a little over £500,000 in 1917 is eloquent of the difficulties that the railway companies have had to face. The average annual value of the imports enumerated in table 4 fell from nearly £14½ millions in the period 1909-1913 to £11¾ millions in the period under review. As in the case of railway material, the fall was due to difficulty in procuring those imports rather than to any decreased demand; the effect, however, has been to make India more self-supporting and to create industries that, in normal circumstances, might not have arisen for many years. The stimulating effect of these conditions on Indian industries of this nature can be gauged from the number of new engineering companies floated during the past few years, and still more by the dividends paid by those already established.

Summary for the Minerals of Group I.

Chromite.

The production of chromite rose from an annual average of 4,671 tons in the preceding quinquennium to nearly 23,000 tons in the period under review. There were continuous increases in the production both in Baluchistan and Mysore, but the rise in the year 1918 was remarkable. This was due to increased demand resulting from the difficulty of finding shipping for New Caledonian ore and from diminution of the Rhodesian output. Hindubagh has now been connected with Quetta by rail, and the greater facilities of transport thus offered have also led to increased activity in Baluchistan.

Table 3.—*Amount and value of Imports of Minerals and products obtained directly from Minerals for the years 1914 to 1918 (including Government Stores).*

—		1914.	1915.	1916.	1917.	1918.	*Average.*
Salt	£	560,657	677,972	1,260,295	1,360,093	1,599,282	*1,091,660*
	tons.	562,448	519,523	446,069	341,986	388,559	*451,717*
Metals— Brass . .	£	91,443	108,236	269,244	391,690	600,618	*292,246*
	cwt.	25,106	24,994	54,485	61,944	90,516	*51,409*
Copper . .	£	2,591,858	1,010,982	514,753	655,038	1,122,892	*1,179,105*
	tons.	706,776	289,274	90,831	100,885	152,965	*268,136*
German Silver .	£	107,508	23,405	4,203	4,827	941	*28,177*
	cwt.	18,779	4,102	493	435	98	*4,781*
Iron . . .	£	274,204	238,406	403,105	438,465	233,851	*317,606*
	tons.	33,684	25,989	25,120	22,497	9,886	*23,425*
Iron or Steel .	£	7,276,789	5,196,734	5,003,957	4,888,314	5,289,928	*5,531,144*
	tons.	630,472	365,412	232,360	151,971	122,140	*300,473*
Steel . . .	£	1,361,937	775,552	656,646	437,519	1,679,264	*982,184*
	tons.	205,821	73,464	39,726	17,478	34,267	*74,150*
Lead . . .	£	196,944	217,454	278,551	257,065	202,679	*230,538*
	cwt.	112,758	168,511	146,122	122,797	101,745	*130,387*
Quicksilver . .	£	13,516	15,745	51,556	44,724	32,587	*31,626*
	lb.	141,599	77,029	219,893	158,317	95,912	*138,550*
Tin . . .	£	303,162	253,826	260,543	324,053	436,751	*327,667*
	cwt.	41,675	30,584	30,037	33,549	37,111	*34,591*
Zinc . . .	£	90,656	58,289	195,200	380,297	371,275	*219,143*
	cwt.	65,120	23,348	49,812	100,069	115,535	*70,777*
Unenumerated .	£	268,400	342,938	162,988	145,562	245,820	*233,042*
	cwt.	71,445	92,791	36,369	28,738	33,956	*52,660*
Total value of metals	£	**12,576,417**	**8,241,567**	**7,800,746**	**7,967,554**	**10,276,106**	**9,372,478**
Inorganic Chemicals	£	694,248	974,938	1,387,231	1,915,064	1,852,191	*1,364,732*
Mineral oil . .	£	3,084,408	2,601,777	2,996,657	2,612,168	2,266,255	*2,712,252*
	gallons	112,012,685	93,251,587	93,184,332	72,419,286	59,686,624	*86,110,903*
Paraffin . .	£	1,261	4,716	23,597	9,018	4,871	*8,693*
	cwt.	1,053	3,974	13,755	3,350	2,362	*4,899*
Coal, Coke and Patent Fuel.	£	637,506	283,785	89,332	92,099	188,759	*258,296*
	tons.	473,496	203,038	37,626	46,455	67,441	*165,610*
Precious Stones and Pearls unset.	£	66,141	326,014	456,538	435,959	206,446	*298,220*
Stone and Marble .	£	29,747	31,173	29,949	32,112	20,690	*28,734*
	cwt.	192,854	157,076	205,729	179,517	131,028	*173,240*
Other Building Materials.	£	671,423	772,111	602,804	787,279	552,191	*677,162*
TOTAL value	£	**18,321,903**	**13,914,048**	**14,647,149**	**15,211,341**	**16,966,291**	**15,212,127**

TABLE 4.—*Value of Imports of products of a more finished nature manufactured almost entirely from minerals or mineral products for the years 1914 to 1918 (including Government Stores).*

—		1914.	1915.	1916.	1917.	1918.	*Average.*
Railway Plant and Rolling stock.	£	9,939,482	5,047,250	1,594,210	535,504	960,138	*3,615,317*
Machinery and Millwork .	£	4,877,254	3,293,544	3,773,962	3,171,738	2,887,357	*3,600,771*
Cutlery and Hardware .	£	2,560,716	1,855,856	2,602,901	2,361,399	2,425,817	*2,361,338*
Glass and Glassware . .	£	828,802	640,455	951,385	1,048,752	890,872	*872,053*
Alizarine and aniline dyes .	£	449,996	110,287	256,331	597,307	825,672	*447,919*
	lb.	11,088,100	964,941	765,590	1,613,196	3,492,953	*3,584,956*
Paints and Colours . .	£	429,806	416,823	639,853	517,746	669,930	*534,832*
	cwt.	370,317	263,181	283,328	242,062	209,116	*273,601*
Earthenware and Porcelain	£	357,040	282,312	338,052	248,736	320,375	*309,303*
TOTAL value .	£	19,443,096	11,646,527	10,156,694	8,481,182	8,980,161	11,741,533

Coal.

In the case of coal, the output increased throughout the period under review; the increase in the last year, however, was remarkable and amounted to 2½ million tons. By the end of that year the Indian output had reached a figure of nearly 21 million tons, representing an increase of 75 per cent. in the course of ten years. Owing to the economic conditions resulting from the war, there has been a marked rise in raising costs, and the pit's mouth value has increased from Rs. 3-9-0 to Rs. 4-6-0; the latter figure, which was reached in the last year of the period under review, is higher than that of any previous year, having surpassed even that reached during the boom of 1908. The increase in value of the output during the past quinquennium is therefore considerably greater relatively than the increase in quantity.

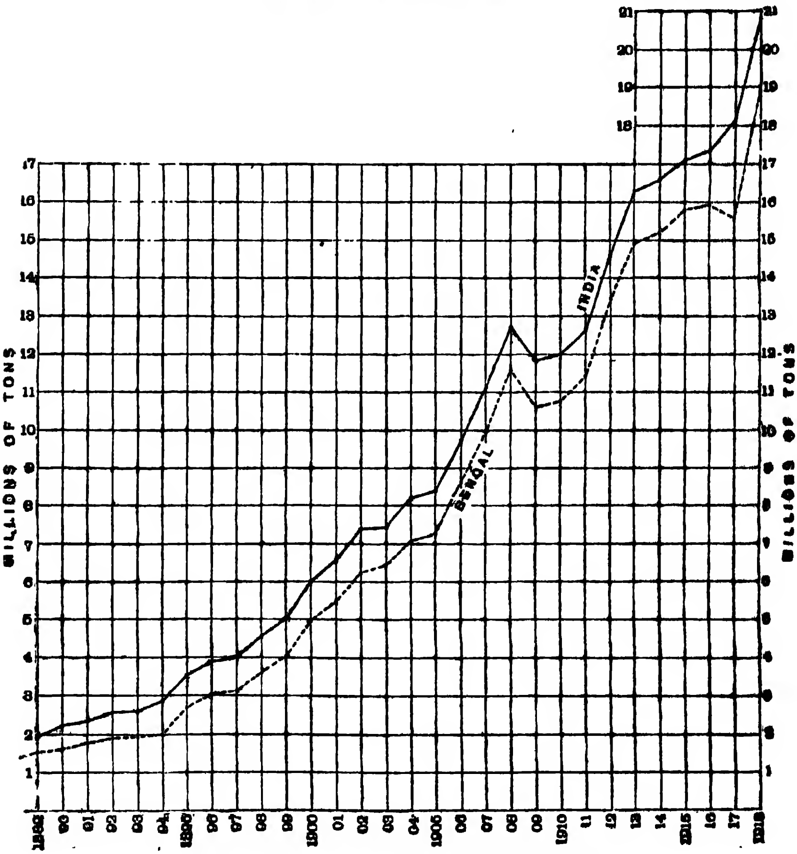


FIG 1.—*Production of Coal from 1889—1918.*

In 1916, India still held her position as the largest coal-producer of any of the British dependencies: figures for other dependencies are not available for later years, but her production was then considerably greater than those of any other dependency. She has, however, been completely outdistanced by Japan, whose output in 1918 was over 27½ million tons against India's 21 millions. The Gondwana fields produced over 98 per cent. of the Indian output, and the Raniganj and Jharia fields respectively 31 and 53 per cent. Ramgarh-Bokaro for the first time took its place among the producing fields, and by the end of the quinquennium its output exceeded those of Pench and Assam and was approaching those of Singareni and Giridih. Before many years this is likely to prove one of the great Indian fields.

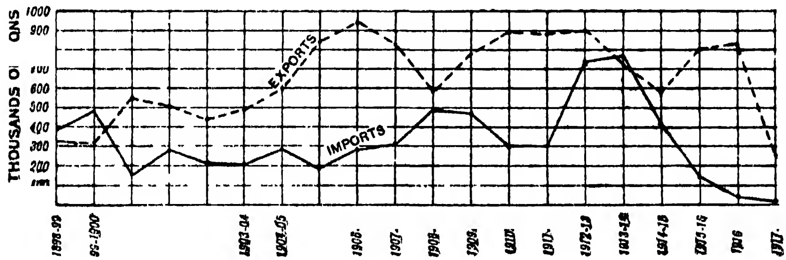


FIG 2.—*Exports and Imports of coal for the past 20 years.*

As might be expected, imports and exports of coal were abnormally low throughout the period under review; imports fell to about 54,000 tons and exports to 74,000 tons in 1918. With increased facilities for freight the export trade will undoubtedly recover, but both Japan and South Africa must be regarded as formidable rivals in Indian Ocean ports. Internal consumption increased largely and amounted to 99·6 per cent. of the output. The actual amount in 1918 was 20,702,386 tons.

Recently the employment of by-product ovens in coke-making has extended considerably. For many years the East Indian Railway Company's Simon-Carves ovens at Giridih constituted the only by-product plant in India; batteries have now been installed in both the chief coalfields. The by-products recovered are tar and ammonia, sulphate being manufactured with acid made locally from imported sulphur.

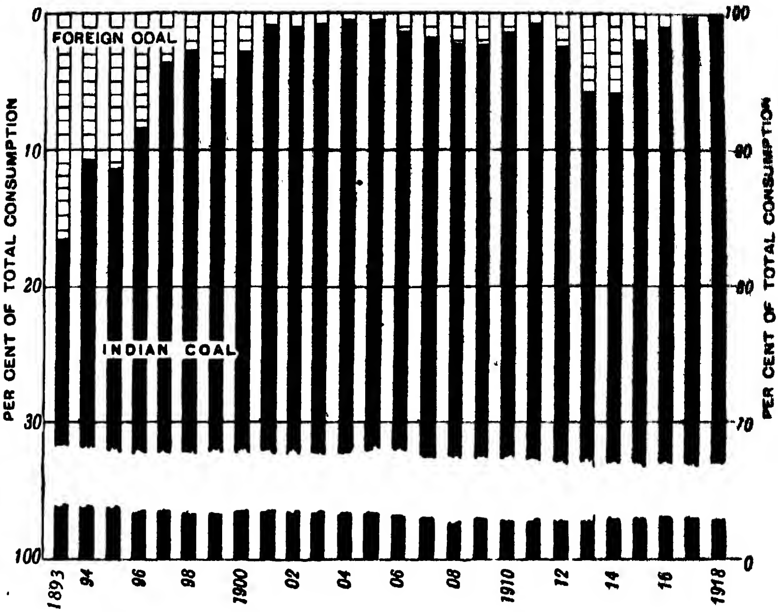


FIG 3.—*The relative consumption of Foreign and Indian coals on Indian Railways during the years 1893—1918.*

Copper.

Copper has now begun to figure regularly in our mineral returns; unfortunately, the Cape Copper Company's operations at Rakha Mines were delayed by the difficulty of importing materials for furnaces, etc., during the war, and the production, which had risen to 20,000 tons in 1917, fell to only 3,600 tons in the last year of the period under review; the average annual output for the whole period was nearly 8,054 tons. Smelting operations were begun in 1918 and a small amount of blister copper produced. With increased facilities, however, and the production of refined copper, the Rakha Mines will no doubt provide an appreciable amount of the copper consumed in this country during the next quinquennial period.

Diamonds.

The output of diamonds has been variable, but still consistently insignificant during the period under review; the largest annual output in any one year was only 73 carats valued at £2,625.

Gold.

Gold-mining was one of the few mineral industries that suffered from the war. The Indian output fell steadily from 1915 onwards, and the output decreased by over 80,000 oz. in 1918. The average annual production for the quinquennial period was a little under 587,000 ounces. Figure 4 shows the output during the last twenty years. The Burma Gold Dredging Company's output from their operations at Myitkyina gradually dwindled, and it was eventually decided to close down; this, however, did not take place till after the close of the period now under review.

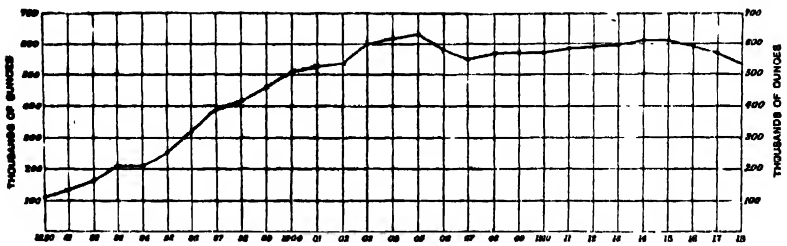


FIG. 4.—*Production of gold since 1890.*

Graphite.

Owing to the difficulty of obtaining graphite from extra-Indian sources, there was a slight revival of indigenous mining. No attempt, however, was made to re-open the Travancore mines, and the production during the period 1915-18 was derived, entirely from Rajputana and Kalahandi.

Iron.

There was a still further advance in the Indian iron and steel trade. The Tata Works at Jamshedpur (Sakchi) increased their output of pig and steel by nearly 100,000 tons, and also produced a certain amount of ferro-manganese in the last year of the period under review. Their output of steel rails also rose to over 70,000 tons. In 1916, the Bengal Iron and Steel Company raised their output of pig to over 90,000 tons and of castings to over 30,000 tons. In the two succeeding years of the period, there was a decline in their production, but against this must be set off the introduction by the same company of the manufacture of ferro-manganese, of which 2,257 tons were produced in 1917 and 12,114 tons in the last year of the quin-

quennial period. There was greatly increased activity in prospecting for iron-ore, and reserves amounting certainly to many hundreds—possibly to thousands—of millions of tons have been discovered in the province of Bihar and Orissa, chiefly in north-western Orissa, Keonjhar and Singhbhum. The recent formation of at least two more Iron and Steel companies promises an early advance in that industry in this country.

Jadeite.

The value of the output of this mineral increased by about 36 per cent., but there has been no advance in the industry, which is a primitive one carried on in the unadministered territory in the neighbourhood of the Hukong.

Lead and Silver.

There has been marked progress in the operations of the Burma Mines, Limited, at Bawdwin and Namtu, and the property is now generally regarded as one of the great lead-silver-zinc mines of the world. The output of metal in 1918 comprised about 19,000 tons of lead and nearly two million ounces of silver.

Magnesite.

The magnesite industry still continued to be erratic, although the average annual output increased by 30 per cent. and the value by three hundred per cent. Most of the output, however, resulted from the temporary closing of European sources of supply during the years 1917 and 1918; this resulted in annual exports of nearly 18,000 tons to England.

Manganese.

In 1907 India overtook Russia which was at that time the greatest producer of manganese and assumed the first place amongst the world's producers of manganese-ore (see fig. 12, p. 157). This lead was lost during the years 1912, 1913 and 1914, but the present trouble in Russia has reinstated India in its former supremacy, in spite of a steady competition with Brazil. The record for the present period has been that of a relatively stable industry that has found its level in the world, the annual fluctuations in output being relatively small and due to changes in market price and rates of freight, and to the gradual development of some deposits and exhaustion of others, whilst the period of discovery of new and valuable deposits of manganese-ore seems to have passed. During the five years 1914-18 the annual production of manganese-ore varied between 450,416 and 682,898 statute tons with an annual average of 577,457 statute tons, the

average annual figures for the two previous quinquennia being 712,797 statute tons in 1909-13 and 509,143 statute tons in 1904-08.

Reliable figures for the Russian manganese-ore production are difficult to obtain but judging from the figures for the years 1914-18 given in *Mineral Industry* for 1918, India will have no difficulty in maintaining her position as premier producer gained in 1908 until the political condition of Russia becomes more stable. It is probable that with a proper organisation of its manganese-ore industry Russia could maintain a leading position, but conditions remaining as they are it is likely that the only immediate rival will be Brazil. During the five years 1908 to 1912 the Indian and Russian productions constituted respectively 43·8 per cent. and 37·2 per cent. of the world's output of manganese-ore, which averaged 1,586,414 metric tons annually.

The average annual value of the ore produced in India during the years 1909-13 was £822,876. This has increased to £1,052,403 for the period 1914-18, the maximum value being £1,372,248 in 1916. Taking the average values for the period, manganese-ore maintains a fourth position amongst the minerals produced in India, being exceeded by coal, gold and petroleum.

From fig. 5 it is seen that the output of the Central Provinces has increased slightly during the period 1914-18, whilst that of Bombay has fallen off slightly. Gangpur in Bihar and Orissa first became a producer in 1908. The production from this State reached its zenith in 1909, subsequently, and in spite of a smart recovery in 1917 and 1918, is still far below what it used to be. Madras shows a very large decrease during the period under review. This is partly due to the decreased output of Vizagapatam on account of the flooding of the two principal mines which had to be closed for about a year after the outbreak of the war and chiefly to the cessation of work in Sandur. Mysore also shows a slight falling-off.

Mica.

During the past quinquennium, India again increased her lead in the production of mica over other producing countries, of which Canada and the United States are of importance. The value of her total output amounted to nearly 72 per cent. of the value of the total output of all the three countries. Recent rivals have sprung up in Natal, and in what was formerly German East Africa but their possibilities are not yet ascertained, and India is still the greatest mica-producing country in the world.

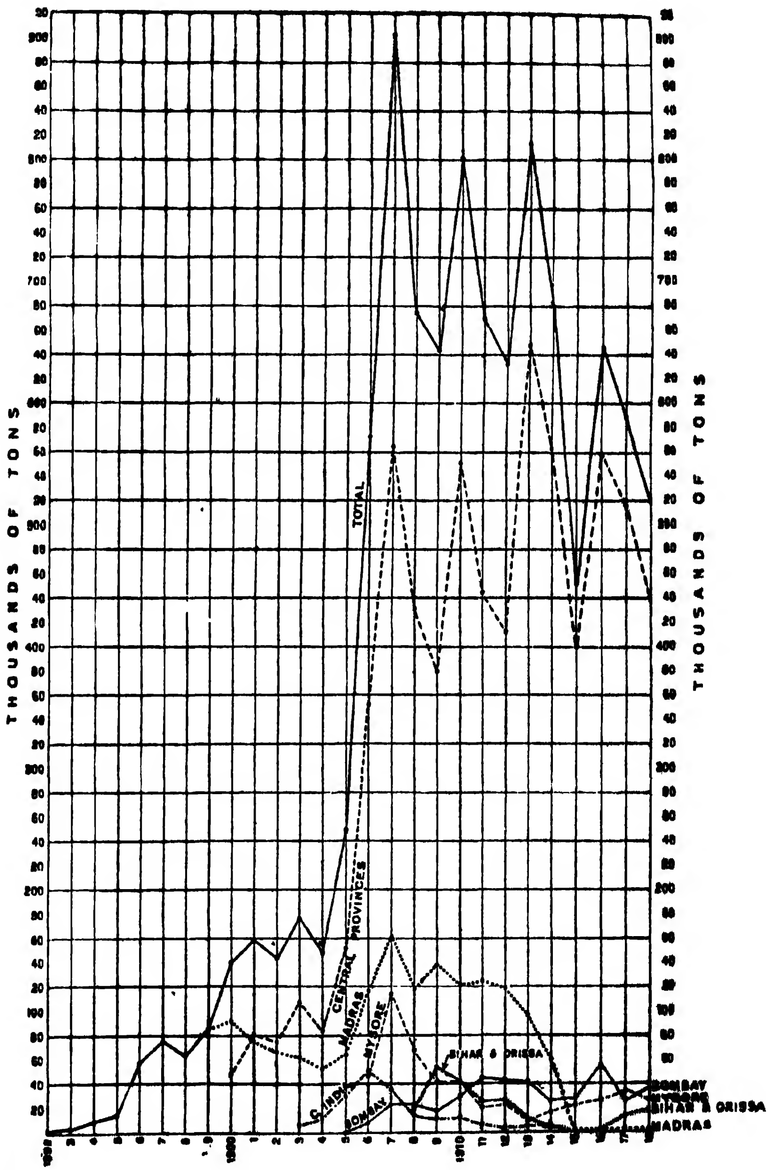


Fig. 5.—*Production of Manganese-ore since the commencement in 1892.*

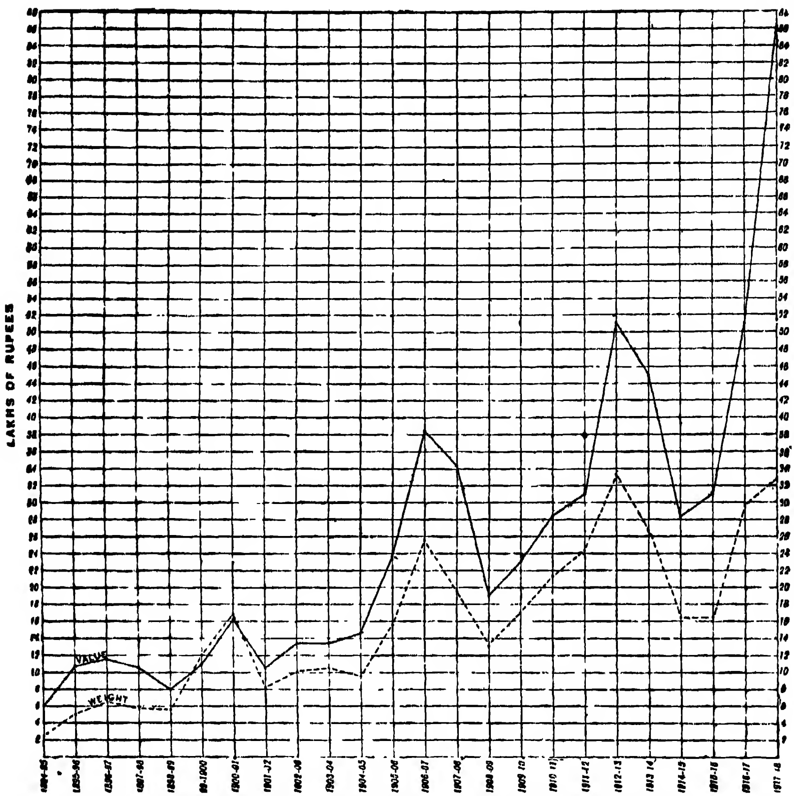


FIG. 6.—*Exports of Indian mica during the years 1894-95 to 1917-18.*

The average annual value of the mica produced in India during the last four quinquennial periods has been :—

	£
1899-1903	85,370
1904-1908	173,511
1909-1913	239,130
1914-1918	383,015

The great increase in value during the period under review is due partly to increased output, but largely to rise in price consequent on the great demand for mica for military purposes during the war. Towards the latter part of the period, the enormous increase in aeroplane production involved the use of large quantities of mica in condensers used in connection with wireless apparatus.

Only Indian mica, and only certain grades of it, were found to be entirely suitable for the purpose.

Fig. 6 shows the fluctuations in the total weight and total value of the mica exported during the past twenty years.

Monazite.

The production of monazite in Travancore remained steady for the earlier part of the period under review, but rose considerably towards the end. The average annual output for the five years was 1,528 tons valued at £45,334.

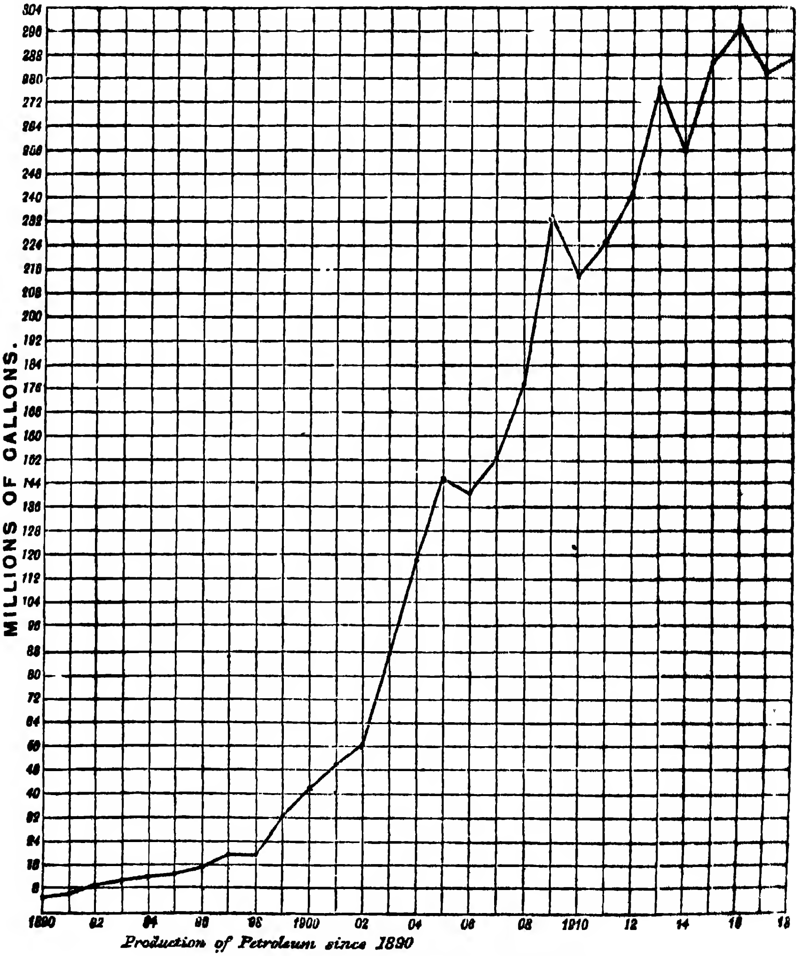


FIG. 7.—*Production of Petroleum since 1890.*

Petroleum.

The production of petroleum has increased from 19 million gallons in 1897 to a record of 297 million gallons in 1916 (see fig. 7). The average annual value of petroleum produced has increased from £928,072 for the period of the preceding review to £1,073,604 for the present period. During the refining of petroleum, paraffin wax, petrol, and other products are obtained; there has been a still further increase during the period in the export of paraffin wax, from 362,676 cwts. in 1914 to 508,964 cwts. in 1918.

Ruby, Sapphire, and Spinel.

Next to petroleum, rubies used to form the chief source of revenue amongst the mineral products of Burma. In recent years however, this industry has been outstripped by those of lead, tin and tungsten. The Burma Ruby Mines, Limited, paid formerly an annual rent of two lakhs of rupees (£13,333) and a royalty of 30 per cent. of their annual net profits. These terms were subsequently modified owing to continued depression in the industry. The average value of the annual output of rubies, sapphires and spinels for the period under review was only £41,817, as compared with £63,272 during the preceding period.

Salt.

The amount of salt produced annually during the period 1914-18 has amounted on an average to over 1,570,000 tons, about 11 per cent. more than the amount produced in the preceding quinquennial period, the average of which was a little over 1,400,000 tons per annum. The annual imports decreased from 552,299 tons in 1909-13 to 443,575 tons in 1914-18. This was only to be expected in view of the freight difficulties arising from the war.

Saltpetre.

Almost every year the figures for the production of saltpetre appear to be understated, being lower than the quantities returned as exports. The saltpetre as exported, however, usually contains a considerable amount of impurity, which if added after the salt has left the hands of the producer would account to some extent for the discrepancy. The average annual exports for the five years amounted to nearly 22,000 tons as compared with nearly 17,000 tons during the period previously reviewed. The value per ton rose by 50 per cent. and the average annual value of the exports during the period of the present review was £517,790 as compared with £252,634 during the preceding period. Almost the whole of the exports during the war went to

the United Kingdom, the remainder being taken by the United States, Mauritius, Ceylon and the Far East.

Tin.

During the period under review the tin-mining industry in Burma again made considerable strides; the value of the output of block tin and tin-ore rose from £46,384 in 1913 to £134,635 in 1918, the annual average for the five years being £73,376 as against £30,096 in the previous quinquennial period. Much of the work was carried out on primitive native principles, but dredging machinery has now been introduced and many of the alluvial flats in Tavoy and Mergui are being systematically tested. The temporary collapse of the wolfram market has led mining concerns to pay more attention to tin, and development should be rapid in the near future. The chief producing areas other than Tavoy and Mergui were Mawchi, in the Southern Shan States, and Thaton.

Tungsten.

The large quantities of high-speed tool-steel required throughout the world in consequence of the war, led to a greatly increased demand for tungsten and its raw materials, wolfram and scheelite. In 1913 the wolfram industry in Burma was only four years old and the output only 1,688 tons. At that time Germany was the only manufacturer of tungsten powder and the allies had previously been dependent on her for their supplies. Steps were therefore taken immediately to set up tungsten works in England and the whole wolfram and scheelite output of the British Empire was commandeered. Vigorous measures were taken to increase production in Burma; by the year 1917 the output had been more than doubled and amounted to 4,542 tons. The value rose in even greater proportion from £175,150 in 1914 to £726,681 in 1918. These figures, however, are artificial; the price per unit was fixed by the British Government at a figure considerably above the previous market rate and all wolfram was taken over at that price. This, although highly profitable to the producer, did not represent the true market value of the material, the price offered in the American market being nearly double the control rate.

III.—DETAILED ACCOUNT OF THE MINERALS OF GROUP I.

Chromite.

[H. H. HAYDEN.]

Chromite is known to occur with serpentine and other rocks of the peridotite family in the "Chalk Hills" near Salem, in the Andamans, in Baluchistan, in Mysore, and in Singhbhum. Attempts were made many years ago to work the deposits near Salem, but were not persisted in. No attempt has been made to work this mineral in the Andamans. Work was commenced on the Baluchistan deposits in 1903, the production for the first year of work being returned as 284 tons. The output from the two producing districts—Quetta-Pishin and Zhob—is shown in table 5, from which it will be seen that

Baluchistan.

TABLE 5.—*Production of Chromite during the years 1914 to 1918.*

PROVINCE.	1914.		1915.		1916.		1917.		1918.		*Average.*	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Baluchistan .	3,006	*1,052*	2,161	*2,161*	7,620	*7,620*	15,659	*15,659*	22,944	*22,944*	10,278	*9,887*
Mysore . .	2,330	*1,258*	1,041	*1,088*	9,802	*6,286*	8,136	*7,146*	33,740	*27,474·3*	11,010	*8,710*
Bihar and Orissa (Singhbhum).	552	*301*	565	*282*	2,737	*2,495*	8,266·4	*3,110*	1,085·5	*1,644·4*	1,641	*1,567*
TOTAL .	5,888	*2,611*	3,767	*3,531*	20,159	*16,401*	27,061·4	*26,215*	57,769·5	*52,062·7*	22,929	*20,164*

there has been a marked increase in the output, that for one year alone, 1918, being greater than the whole output of the preceding quinquennial period (1909-13). The annual average output of Baluchistan for the period under review was 10,278 tons, being an increase of over 300 per cent. The chromite exported from Karachi, is of high grade, occurring as veins and irregularly segregated masses in serpentine formed by the alteration of enstatite-peridotites (saxonites) of upper Cretaceous age.[1]

[1] E. Vredenburg, *General Report, Geol. Surv. Ind.*, for 1902-03, p. 9; L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLVIII, p. 12.

Mysore.

In Mysore State chromite occurs in the districts of Mysore, Hassan, and Shimoga. It has been worked in the first two districts only, the production for 1907, the first year of work, being 11,029 tons. There was little activity in the earlier years of the period under review, but in the last year, 1918, a company holding a prospecting license worked with great vigour for some time and the output of the State rose to 33,740 tons much of it said to be high-grade ore. The average annual output of Mysore for the quinquennial period was 11,010 tons.

Shimoga district.

Chromite seems to have been first found in Mysore by the late Mr. H. K. Slater, who found a rock showing grains of chromite in a talcose matrix near Harenhalli in the Shimoga district.[1] Even the richest specimens did not indicate more than 35 to 40 per cent. of Cr_2O_3.

Mysore district.

The most important of the Mysore chromite deposits is situated near the village of Kadakola in the Mysore district (first taken up on license in 1906). The 'country' consists of gneiss with occasional patches of hornblende-schist. It is cut by a couple of ultra-basic dykes of the dunite series, one of which has been completely altered to serpentine for a length of about two miles. The chromite occurs for the most part as a narrow vein, averaging, probably, not more than 9 to 12 inches in thickness. But in one place it forms a large lens. Several thousand tons of chromite have already been quarried in this area. The ore is of fairly good quality, often yielding on analysis from 50 to 52 per cent. of Cr_2O_3; but a considerable proportion of it is probably of lower grade.[2]

Hassan District.

Chromite was found in the Hassan district in 1906 over a length of about 20 miles, in some altered ultra-basic rocks—tremolite and enstatite largely altered to talc and serpentine—located in a belt of hornblendic schists. The ore consists, for the most part, of small grains of chromite embedded in a talcose matrix. Some of the better portions of the rock probably contain 30 to 40 per cent. of Cr_2O_3.

Operations, however, have been largely confined to Mr. J. Burr's block at Kadakola, the output from which was 4,727 tons in 1909, of which only 3,320 tons were sold the same year. Owing

[1] *Rec. Mysore Geol. Dept.*, II, p. 129.
[2] Report, Chief Inspector of Mines, Mysore, for 1906-07, p. 36.

to low prices, mining ceased for the next three years, but there were signs of a revival in 1912, eight prospecting licenses being taken out in Mysore district and one in Hassan district; in 1913, as stated above, mining was resumed.[1]

Singhbhum.

A geological survey of the chromite area to the west of Chaibasa in Singhbhum discovered by the late Mr. R. Saubolle in 1907 has shown that the ore occurs as bed-like veins and as scattered granules in serpentinized saxonites and dunites forming laccolitic intrusions several hundred feet thick in Dharwar slates and slaty shales. As in Baluchistan the chromite is of primary (magmatic) origin contemporaneous with the peridotites. The subsequent serpentinization of the peridotites has been accompanied by widespread silicification with production of marginal zones of chert. The ore-bearing horizon is unusually persistent over a considerable distance, but the total amount of ore available does not appear to be large. As exported the ore carries 50 per cent. Cr_2O_3 and upwards but the possibility of treating in concentration mills ores of lower grade at present rejected may be worth consideration.[2]

Coal.

[H. H. HAYDEN.]

Progress in output.

Since the year 1882 the expansion in the coal mining industry has been uninterrupted, and during the past ten years the production has again been nearly doubled. In the quinquennial period under review, the total production rose from 16,464,263 tons in 1914 to 20,722,493 tons in 1918, an increase of nearly 25 per cent. The annual figures for production and value during the quinquennial period are shown in table 6.

TABLE 6.—*Production and Value of Coal during the years 1914 to 1918.*

YEAR.	Quantity.	Total value at the mines.		*Average value per ton at the mines.*	
	Tons.	Rs.	£	Rs. A.	*s. d.*
1914 . . .	16,464,263	5,86,10,698	3,907,380	3 9	*4 9*
1915 . . .	17,103,932	5,67,15,955	3,781,064	3 5	*4 5*
1916 . . .	17,254,309	5,81,78,459	3,878,564	3 6	*4 6*
1917 . . .	18,212,918	6,76,74,681	4,511,645	3 11	*4 11*
1918 . . .	20,722,493	9,02,58,224	6,017,215	4 6	*5 10*

[1] *Annual Reports of Chief Inspector of Mines, Mysore.*
[2] L. L. Fermor, *Rec. Geol. Surv. Ind.*, *XXXVIII*, p. 34; *ibid.*, L. p. 10. *Proc. Asiat. Soc. Beng.*, New Series XV, p. clxxxiii.

TABLE 7.—*Average pit's mouth value (per ton) of Coal extracted from the mines in each province during the years 1914 to 1918.*

PROVINCE.	1914.	1915.	1916.	1917.	1918.	Average.
	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
Assam . .	7 0 1	6 15 6	6 15 10	7 0 7	7 2 8	7 0 6
Baluchistan . .	9 9 0	9 11 9	10 8 10	11 0 11	14 13 8	11 2 5
Bengal . .	3 13 10	3 6 2	3 8 9	3 15 1	4 14 10	3 14 11
Bihar and Orissa .	3 3 4	2 15 6	2 15 10	3 5 10	3 14 3	3 4 7
Central India .	3 0 0	3 0 0	3 0 0	3 6 2	4 8 1	3 6 1
Central Provinces .	4 7 3	4 4 6	4 1 1	4 1 3	5 9 0	4 7 10
North-West Frontier Province	5 0 0	5 0 0	5 0 0	14 0 0	4 0 0	6 9 7
Punjab . .	5 3 0	5 6 11	6 14 5	7 8 8	11 5 0	7 4 5
Rajputana . .	3 14 9	3 15 2	3 12 4	4 5 8	6 5 5	4 7 6

It should be remembered that the values given in the above tables are intended to represent wholesale prices at the pit's mouth; these include all grades, and are also necessarily dependent upon the relation between local supply and demand, not indicative of the actual value of the fuel. Bengal coal, which is all round the best quality worked in India, is returned as having a lower value than the coal worked in other provinces, where higher prices can be safely demanded by the miner. During the period under review, the price f.o.r. at the mine of the best quality of Bengal coal (Dishargarh) fell from Rs. 7-5-0 per ton in 1914 to Rs. 5-1-4 in 1916; in 1917 all first-class coal was requisitioned and controlled by Government, and prices were fixed by the Coal Controller; the figures for the years 1917 and 1918, therefore, have no statistical value. Although, except for part of the year 1918, only first-class coal was requisitioned, the control inevitably reacted on the price of second-class, for the better material being no longer procurable in the open market, its place was taken by the inferior, which, being uncontrolled, frequently sold at higher prices than were being paid by the Controller for first-class coal.

The average cost of coal to the consumer in India is low compared with that in most of the principal coal-producing countries

of the world. The declared pit-mouth values per ton in some other countries during the years 1913 to 1916 were :—

	s.	*d.*
United Kingdom	12	0¼
United States	6	1½
Australia	7	8¼

Comparison of India with Australia, Canada and South Africa.

As will be seen from table 8, up to the end of 1916 India still maintained her lead in output over all other British dependencies, but figures for the last two years of the period are not yet available. It is interesting to note also that India's share of the total output of the British Empire has risen from 3·65 per cent. during the period 1903-07 to 5·3 per cent. in 1913-16. In 1915 the production of this country exceeded that of Australia by 5¾ million tons and of Canada by 5⅓ million. The cause of this is doubtless to be found in the greatly increased industrial activity of India, leading not only to an increased consumption of coal in the producing industries, such as jute and cotton, but also to an increased consumption of coal on the railways engaged in the carriage of the products of India's industrial and agricultural activity; and as but a small proportion of the Indian coal is exported, this largely increased production may be regarded as an index of increase in the prosperity of the country.

TABLE 8.—*Production of Coal in the four largest British Dependencies.*

COUNTRIES.	1913. Metric Tons.	*Per cent. of British output.*	1914. Metric Tons.	*Per cent. of British output.*	1915. Metric Tons.	*Per cent. of British output.*	1916. Metric Tons.	*Per cent. of British output.*
India . .	16,467,337	4·77	16,727,691	5·19	17,377,595	5·64	17,530,378	5·61
Australia . .	12,616,552	3·66	12,643,985	3·92	11,598,098	3·76	9,969,080	3·10
Canada . .	13,618,190	3·95	12,371,187	3·87	12,035,085	3·90	13,138,508	4·20
South Africa .	7,983,960	2·31	7,690,687	2·39	7,512,344	2·44	9,078,134	2·91
TOTAL for British Empire	344,632,612	..	322,260,597	..	308,024,462	..	312,486,721	..

Comparison of India with Japan.

Already before the war a serious competitor of India for the supply of coal to Eastern ports, Japan maintained her lead, particularly in the Straits Settlements; but her exports to Ceylon fell off. But statistics of this kind for the period under review are of little value, owing to the entirely artificial conditions prevailing throughout. A reference to table 9 will show that in production Japan has now well out-distanced India. At the same time, the quantity of coal retained for consumption in Japan is greater than the amount consumed in India. In making this comparison it must be remembered that a given consumption of coal in Japan registers a much greater proportional industrial activity than does the same consumption of India, on account of the much smaller population of the former country.

TABLE 9.—*Comparison of the Indian and Japanese Coal Statistics.*

Year.	Production.		Imports.		Exports.		Quantity retained for consumption in Japan.
	India.	Japan.	India(*a*).	Japan.	India(*a*).	Japan.	
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1885 .	1,294,221	1,294,000	790,930	12,876	750	191,802	1,115,074
1890 .	2,168,521	2,566,551	784,664	12,301	26,649	853,720	1,725,132
1895 .	3,540,019	4,733,861	761,996	68,931	81,126	1,376,068	3,426,724
1900 .	6,118,692	7,369,068	135,649	108,593	490,491	2,402,785	5,074,876
1905 .	8,417,739	11,407,799	197,784	329,495	783,051	2,507,527	9,229,767
1909 .	11,870,064	14,732,970	490,421	129,858	563,940	2,798,563	12,064,265
1913 .	16,208,009	20,973,384	644,934	567,502	759,210	3,808,394	17,732,492
1914 .	16,464,263	21,825,753	418,758	942,318	579,763	3,529,161	19,238,910
1915 .	17,103,932	20,161,431	190,654	599,999	753,105	2,854,264	17,907,166
1916 .	17,254,309	22,533,519	34,033	547,173	882,454	2,968,460	20,112,232
1917 .	18,212,918	25,937,754	44,818	701,620	409,215	2,768,246	23,871,128
1918 .	20,722,493	27,578,952	54,346	755,452	74,466	2,161,727	26,172,677

(*a*) Excludes Government stores.

Relation of consumption to production.

Hitherto the market for Indian coal has necessarily been limited to (1) the home industries, and (2) the Indian Ocean ports, where the manufacturing industries requiring coal are comparatively few, and where India is not the sole supplier of fuel. Tables 10 and 14 show that, during the five years under review, India consumed on an average 96·9 per cent. of the coal produced in the country, and, in addition, imported annually on an average 148,522 tons of foreign coal. This compares with an average consumption during the preceding period of 93·9 per cent. of the coal produced in the country, in addition to an annual import of 466,162 tons of foreign coal.

The actual annual consumption since 1914 has been, on the average 17,562,374 tons, whilst the production during the same period has averaged 17,951,583 tons. As the consumption and production are so nearly alike, it is evident that the great expansion that has taken place in the Indian coal trade must be due, as already noted, to industrial developments in India itself. It has hitherto had little to do with increased facilities of transport and of consequent access to new markets, and this was even more the case during the war (see table 13), when Indian exports, which have always been very small, were still further reduced. The average annual exports for the five years 1914-18 were only 539,422 tons as compared with 814,475 tons for the previous five years 1909-13.

TABLE 10.—*Relation of Consumption to Production.* (*a*)

YEAR.	Total consumption of coal in India.	CONSUMPTION OF INDIAN COAL IN INDIA.	
		Quantity.	*Percentage of Indian production.*
	Tons.	Tons.	
1914	16,308,536	15,882,715	*96·5*
1915	16,543,582	16,349,649	*95·6*
1916	16,407,762	16,369,657	*94·9*
1917	17,849,602	17,793,762	*97·7*
1918	20,702,386	20,647,896	*99·6*
Average	*17,562,374*	*17,408,736*	*96·9*

(*a*) The consumption of coal is assumed to be production *plus* imports *minus* exports. In the imports and exports a ton of coke is taken to be equivalent to 2 tons of coal. The imports exclude Government stores.

Consumption of coal on Indian railways.

In spite of restriction of traffic consequent on shortage of rolling-stock, the period of the war has shown a still further increase in the amount of coal consumed on the railways in India. The average annual consumption during the period under review was over 5¼ million tons as compared with a little over 4 million in the preceding quinquennium. Yet the relation between the consumption of coal on the railways and in the various industrial enterprises in the country keeps a fairly constant ratio. During the three previous quinquennial periods the Indian coal consumed on the railways was on an average 30 per cent. of the total production, while during the past five years the average percentage has been 28·8. Foreign coal was rapidly displaced by the Indian product after 1888, when it amounted to 31 per cent. of the total. Since 1900 the Indian collieries have supplied 98 per cent. or more of the total railway requirements, and as might have been expected the percentage rose during the last years of the war and for the period April 1st, 1917—March 31st, 1918 was 99·9.

TABLE 11.—*Coal consumed on Indian Railways during the years 1913-14 to 1917-18.*(*a*)

YEAR.	INDIAN COAL.		FOREIGN COAL.		Total consumption.
	Quantity.	*Per cent. of Total.*	Quantity.	*Per cent of Total.*	
	Tons.		Tons.		Tons.
1913-14	4,702,479	*94*	298,582	*6*	**5,001,061**
1914-15	4,948,310	*98·2*	89,211	*1·8*	**5,037,521**
1915-16	5,145,746	*99·2*	40,959	*·8*	**5,186,705**
1916-17	5,496,239	*99·8*	13,162	*·2*	**5,509,401**
1917-18	5,616,725	*99·9*	3,620	*·1*	**5,620,345**
Average .	*5,181,900*	...	*89,107*	...	*5,271,007*

(*a*) Statistics for calendar years are no longer available.

Earnings from transport of coal.

The transport of coal forms an important item in the earnings of the Railway Companies, especially the East Indian and Bengal-Nagpur systems which serve the Raniganj, Jharia, Giridih, and the fields of the Central Provinces.

Details are shown in table 12. This table excludes coal carried by railways for their own consumption.

TABLE 12.—*Coal carried for the Public and Foreign Railways during the years 1913-14 to 1917-18.*

—	Coal carried on Indian Railways.	Earning of Railways from coal traffic.
	Millions of Tons.	£, Millions.
1913-14	17·29	3·30
1914-15	18·47	3·75
1915-16	19·06	4·19
1916-17	22·39	5·32
1917-18	12·82	5·50

In normal circumstances, most of the coal consumed at Indian ports is carried from Calcutta by sea, for although the rates charged on Indian railways are low,[1] sea-freight to ports has in the past always been cheaper, and the railways have been used only for internal distribution.

[1] The rates are :—
for the first 75 miles—0·14 pie per maund (of 82 lbs.) per mile;
from 76th to 200th mile—0·12 " " "
from 201st to 500th mile—0·06 " " "
501st mile and beyond—0·05 " " "
These may be illustrated by a few examples :—

	Freight per ton of coal. Rs. a.	s. d.
for 75 miles	1 9	= 2 1
" 200 "	3 11	= 4 11
" 500 "	6 4	= 8 4
" 1,500 "	13 5	=17 9

*Lack of sea-freight during the period under review threw practically the whole coal traffic on to the railways, and exports to Indian ports by sea fell to practically nothing. Detailed figures are not available for all Indian ports, but the case of Chittagong will serve as an example; in the year 1914, the imports of coal by sea from Calcutta into that port amounted to over 26,000 tons; in 1918 they fell to 370 tons.

Imports and exports.

Table 13 shows the relation between the imports of foreign coal and the exports of Indian coal during the past ten years. The decreases in both imports and exports were inevitable and are of no statistical value. The average amounts imported and exported annually during the period 1914-18 were 148,522 tons and 539,422 tons respectively, as compared with 466,162 tons and 814,475 tons for the period 1909-13. There was a particularly marked drop in exports during the last year of the period.

TABLE 13.—*Imports and Exports of Coal during the years 1909 to 1918.*

YEAR.	Imports.	Exports.
	Tons.	Tons.
1909	490,421	563,940
1910	315,906	988,366
1911	318,669	862,177
1912	560,791	898,739
1913	644,934	759,155
1914	418,758	579,746
1915	190,654	753,042
1916	34,033	881,741
1917	44,818	408,117
1918	54,346	74,466
Average	*307,342*	676,949

TABLE 14.—*Origin of foreign coal imported into British India.*

YEAR.	From United Kingdom.	From Australia.	From Natal.	From Japan.	From Portuguese East Africa.	From Transvaal.	From other Countries.	TOTAL.
1914 .	167,176	33,419	39,140	32,234	58,742	40,355	47,692	**418,758**
1915 .	47,343	28,106	15,292	18,069	52,312	26,448	3,084	**190,654**
1916 .	5,492	12,301	10,799	...	3,587	...	1,854	**34,033**
1917 .	6,903	22,554	3,857	448	9,080	...	1,976	**44,818**
1918 .	8,724	4,857	13,020	3,276	22,680	...	1,789	**54,346**
Average .	*47,128*	*20,247*	*16,422*	*10,805*	*29,280*	*13,361*	*11,279*	*148,522*

Exports.

The distribution of exported Indian coal is shown in table 15, from which it will be seen that the export trade to Far Eastern ports was practically extinct by the end of the period under review. This, however, will no doubt be recovered with increased shipping facilities, but Japan must remain a formidable rival in those markets.

TABLE 15.—*Exports of Indian coal.*

—	1914.	1915.	1916.	1917.	1918.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Aden . .	16,537	10,717	19,386	419	53	*9,422*
British East Africa	...	...	10	4	...	*3*
Mauritius . .	1,249	1,945	992	...	...	*837*
Ceylon . .	341,126	555,241	549,565	299,507	52,040	*359,496*
Java . .	51	12,050	30,380	...	...	*8,496*
Straits Settlements.	111,589	99,483	142,025	80,531	10,279	*88,782*
Sumatra . .	83,739	64,373	104,121	8,474	...	*52,141*
Other countries .	25,455	9,233	35,262	19,182	12,094	*20,245*
TOTAL, Exports	**579,746**	**753,042**	**881,741**	**408,117**	**74,466**	***539,422***
	£	£	£	£	£	£
VALUE .	341,124	460,197	535,193	252,558	52,344	*328,483*

Possible expansion of the export trade.

The two tables 16 and 17 show the extent of the two chief markets for which India has to compete with Australia, Japan, and Natal. The British coal taken in Ceylon and the Straits Settlements has not all been in competition with Indian coal, for some steamers were compelled to accept the high quality of steaming fuel from

England in spite of the comparatively low prices of material obtainable from India and the Pacific. The variations in the share which India takes in these markets have never been of much value as an index to the growth of the industry; the collieries have often been barely able to meet the domestic demand, and Indian consumers complain no less than outside customers of the quantities of low-grade fuel forced on them during a boom.

It is impossible at present to say if there is any great future for Indian coal in Pacific ports; the principal competitors have hitherto been Japan and Australia, and if those two countries find domestic markets for their coal in their own industrial developments, China is known to possess large deposits, which, however, will remain locked up until greater transport facilities are provided from the fields to the coast. The enormously increased cost of English and Welsh coal and its diminished production now offer to India a remarkable opportunity for export to Egypt and possibly even to Mediterranean ports.

TABLE 16.—*Foreign Coal Imports of Ceylon for the years 1914 to 1918.*

ORIGIN OF THE COAL.	1914.	1915.	1916.	1917.	1918.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom	263,054	57,325	39,256	17,417	187	*75,448*
British India .	269,575	451,962	446,437	227,261	71,044	*293,256*
Japan . .	10,340	17,516	19,776	8,201	10,537	*13,274*
Other countries .	55,988	114,783	70,208	58,817	136,582	*87,275*
TOTAL, Imports	**598,957**	**641,586**	**575,677**	**311,696**	**218,350**	***469,253***

TABLE 17.—*Imports of Coal into the Straits Settlements for the years 1914 to 1918.*

ORIGIN OF THE COAL.	1914.	1915.	1916.	1917.	1918.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
United Kingdom	47,264	3,414	24,691	406	...	*15,155*
British India .	123,047	93,740	135,160	89,161	19,482	*92,118*
Australia . .	175,534	49,940	31,855	39,681	8,074	*61,017*
Japan . .	463,014	419,274	391,989	408,502	370,345	*410,625*
Other countries .	190,882	151,205	178,156	101,912	98,590	*144,149*
TOTAL, Imports	**999,741**	**717,573**	**761,851**	**639,662**	**496,491**	***723,064***

Table 18 shows the average quantity of coal shipped annually from Calcutta to other Indian ports. This is of little value during the period except to show the complete breakdown of coastal trade during the latter part of the war.

Calcutta exports.

TABLE 18.—*Statement showing the Exports of Coal from Calcutta to Indian ports during the years 1914 to 1918.*

PORTS.	1914.	1915.	1916.	1917.	1918.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Bengal, All ports	28,033	23,471	6,861	600	...	*11,793(a)*
Bihar and Orissa	807	1,266	1,841	999	108	*1,004*
Bombay, Chief port.	784,991	323,361	...	...	2,497	*222,170(a)*
Bombay, Other ports.	2,500	4,354	795	...	...	*1,530(a)*
Burma, Chief port.	418,409	419,803	431,074	239,391	81,910	*318,117*
Burma, Other ports.	18,320	16,718	6,123	7,973	2,334	*10,294*
Cutch, Tuna .	40	135	...	...	...	*35(a)*
Cutch, Mundra .	...	40	...	...	...	*8(a)*
Goa . .	47,349	...	...	...	...	*9,470(a)*
Gujrat, Bilemora	159	130	...	...	...	*58(a)*
Kathiawar, Bhavnagore.	5,222	727	...	...	...	*1,190(a)*
Kathiawar, Mahuva.	252	...	51	...	...	*60(a)*
Madras, Chief port.	136,200	70,703	29,222	11,460	6,180	*50,753*
Madras, Other ports.	210,001	219,433	48,678	160	100	*95,674*
Pondicherry .	4,481	1,510	1,380	2,074	...	*1,889(a)*
Sind, Karachi .	391,985	106,205	...	...	...	*99,638(a)*
TOTAL .	2,048,749	1,187,856	526,025	262,657	93,129	*823,683*

(*a*) Average of five years.

TABLE 19.—*Output of Indian Coal by Provinces for the years 1914 to 1918.*

PROVINCE.	1914.	1915.	1916.	1917.	1918.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Assam . .	305,160	311,296	287,315	301,480	294,484	1,499,735
Baluchistan .	48,234	43,607	42,163	40,785	43,125	217,914
Bengal . .	4,424,557	4,975,460	4,992,376	4,631,571	5,302,295	24,326,259
Bihar and Orissa	10,661,062	10,718,155	10,767,683	11,932,419	13,680,030	57,759,349
Burma . .	..	25	..	..	..	25
Central India .	152,906	139,680	200,285	198,407	199,975	891,253
Central Provinces	244,745	253,118	287,832	371,498	481,470	1,638,663
Hyderabad .	555,991	586,824	615,290	680,629	659,122	3,097,856
North-West Frontier Province.	94	60	75	215	240	684
Punjab . .	54,303	57,911	47,449	49,869	50,418	259,950
Rajputana (Bikanir).	17,211	17,796	13,841	6,045	11,334	66,227
TOTAL .	16,464,263	17,103,932	17,254,309	18,212,918	20,722,493	89,757,915

Provincial production.

Table 19 shows the provincial production for the years 1914 to 1918. It will be seen that Bengal and Bihar, which yield Gondwana coal only, increased their output from 15 million tons in 1914 to nearly 19 million tons in 1918. Among the other provinces, Baluchistan shows no pronounced change since 1903. In the following year the production reached nearly 50,000 tons and then fell back to between 41,000 and 45,000 tons. It rose in the period 1909-13 to an annual average of nearly 52,000 tons, but fell again in the period under review to an average of less than 44,000 tons per annum. The production recorded for Central India is entirely that due to the Umaria collieries, where there has been a slight rise in production during the past five years. In the Central Provinces, where the production varied for many years between 140,000 and 190,000 tons, the sudden drop in 1906, due to the closing down of the Warora colliery, was only partially compensated for by increased activity in the Pench Valley area and at Mohpani. The rapid rise during the years 1907 and 1908 was due largely

to increased production in the Pench Valley field, but partly also to the development of new collieries at Ballarpur in the Chanda district. During the past five years 1914-18 the production has risen by nearly 100 per cent. to nearly 500,000 tons in 1918. The production of Assam is nearly all due to the coal mines in the neighbourhood of Margherita in the Lakhimpur district of North-eastern Assam. The production in this area reached its maximum in 1915 but is limited mainly by the difficulties due to working inclines in thick seams liable to spontaneous combustion. The production recorded for Hyderabad is due to the mines at Singareni, which after maintaining an average output of between 400,000 and 500,000 tons for many years, increased their production considerably during the war, the output in 1917 being over 680,000 tons. There has been no noteworthy change in the production of the Punjab, where the only coal obtained is from the mines in the Tertiary rocks of the Salt Range area. The production recorded for Rajputana is that of the Palana colliery in the Bikanir State. The maximum production of this colliery occurred in 1904, when 45,000 tons were obtained. Since then there has been a noticeable decline in the output; the annual average of which was only 13,245 in the period 1914-18 as against a little over 15,000 tons in 1909-13. The lowest figure, 6,045 tons, was reached in 1917, since when there has been a slight improvement the output for 1918 having been over 11,000 tons.

Geological Relations of Indian Coal.[1]

The Gondwana system.

The formation from which nearly 98 per cent. of the coal supplies of India is obtained was named the *Gondwana* system by H. B. Medlicott in 1872.[2] It is 'chiefly composed of sandstones and shales, which, except for some exposures along the East Coast, appear to have been entirely deposited in fresh water, and probably by rivers.'[3]

The lowest division of the system is known as the *Talchir* series from its original discovery in the small State of that name in Orissa.[4]

[1] See also V. Ball and R. R. Simpson: The Coalfields of India, *Mem. Geol. Surv. Ind.*, XLI, pt. 1 (1913).

[2] F. Stoliczka, *Rec. Geol. Surv. Ind.*, IX, p. 28 (1876); and *cf. Rec. Geol. Surv. Ind.*, XIV, p. ii (1881).

[3] R. D. Oldham, Medlicott and Blanford, Manual, Geol. Ind., 2nd Ed., p. 149 (1893).

[4] T. Oldham, *Mem. Geol. Surv. Ind.*, I, p. 46 (1856).

The beds of this series are of small thickness; but they are known, and, from their peculiar features, easily recognised in most of the coalfields. They include boulder-beds supposed to be due to glacial action, and are thus regarded as similar in origin, probably also corresponding in geological age, to the Dwyka formation which lies at the base of the similar coal-bearing Karoo system in South Africa.

The only part of the Gondwana system which is important from the coal-producing point of view is that distinguished as the *Damuda* series,[1] from its development in the valley of the Damuda river. In the Raniganj and Jharia fields this series can be subdivided into three stages, of which that distinguished as the ***Barakar*** below, and that known as the ***Raniganj*** stage above, the ***Ironstone shales***, both include valuable coal-seams. The Raniganj stage produces the principal part of the supplies obtained from the Raniganj field; but seams in this stage of the Jharia field are generally thinner and poorer than those in the Barakar stage.

Age of the Lower Gondwana coal-measures.

The absence of marine formations throughout the lower division of the Gondwana system made it impossible at first to determine with any precision the geological age of the coal-measures with reference to the recognised standard stratigraphical scale of Europe. The geologists who first separated the Talchirs from the overlying strata of the Gondwanas regarded them on slender indirect evidence as probably not more recent than Permian in age.[2] On account of the affinities of the plant remains in the Lower Gondwanas, they were regarded as Triassic while the Rajmahal beds in the Upper Gondwanas were considered to be Jurassic.[3] A reconsideration of the fossil evidence and comparison with similar beds associated with marine formations in Australia tended to confirm the earlier conclusions regarding the Palæozoic age of the Lower Gondwanas.[4] The discovery of typical Lower Gondwana plant remains embedded in marine formations in Kashmir, where they were deposited probably near the mouth of one of the great rivers flowing from Gondwanaland into the great ocean then covering the area now occupied by Central Asia, confirms the conclusion

[1] T. Oldham, *Journ. As. Soc. Bengal*, XXV, p. 253 (1856).
[2] W. T. and H. F. Blanford and W. Theobald, *Mem. Geol. Surv. Ind.*, I, p. 82 (1859).
[3] O. Feistmantel, *Rec. Geol. Surv. Ind.*, IX, p. 79 (1876).
[4] See recapitulation by W. T. Blanford, *Rec. Geol. Surv. Ind.*, IX, pp. 79—85 (1876).

regarding the Palæozoic age of the Lower Gondwanas: these Gondwana plants have been found in beds that are certainly not younger than Upper Carboniferous.[1] Thus, the Indian coal-measures are not much younger than, and may even be of the same age as, those of Europe.

Although there are coal-seams in the Jurassic rocks of Cutch and in the Cretaceous beds of Assam, all the coal being worked outside the Gondwana fields is of Tertiary age.

Eocene coal : Palana.

At Palana in the Bikanir State, Rajputana, a lignitic coal containing small nodules of resin lies immediately underneath Nummulitic limestones,[2] from which characteristic Lutetian (middle Eocene) fossils have been obtained.[3]

Tertiary coal in Assam.

Coal of the same age is being worked in the Punjab and Baluchistan, while some of that worked on a small scale in the Khasi and Jaintia Hills of Assam is also associated with Nummulitic rocks. The thick seams of the Lakhimpur district, which yield most of the coal now mined in Assam, belong to a series of beds whose age is not determinable by direct evidence, as they have not been found in contact with any fossiliferous marine formations. The same series yields the petroleum of the Digboi area, and because of this circumstance together with the fact that the overlying sandstones resemble the Pliocene Irrawadi series overlying the Miocene oil-bearing strata in Upper Burma, there is a temptation naturally to regard the Lakhimpur coal and associated petroliferous beds as Miocene in age.

Some of the small coal basins on the Assam plateau are said to be of Cretaceous age, the coal in them being always characterised by the presence of lumps of fossil resin like those found in the Palana lignite.

Geological origin of the coal.

Table 20 shows the origin of the coal produced during the years 1914 to 1918. It will be noticed that the output from the Gondwana coalfields which in the period 1904-08 averaged 95·85 per cent.

[1] H. H. Hayden, *Rec. Geol. Surv. Ind.*, XXXVI, p. 38 (1907); C. S. Middlemiss, *Rec. Geol. Surv. Ind.*, XXXVII, p. 286 (1909).
[2] T. D. LaTouche, *Rec. Geol. Surv. Ind.*, XXX, pp. 122—125 (1897).
[3] E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVI, p. 314 (1907).

of the total production, has gradually become a larger fraction of the total. In 1909, 96·57 per cent. of the coal was obtained from the Gondwana fields, and 3·43 per cent. from Tertiary beds, while in 1918, 98·08 per cent. of the total belonged to the former category and only 1·92 per cent. was Tertiary coal.

TABLE 20.—*Origin of Indian Coal raised during the years 1914 to 1918.*

YEAR.	FROM GONDWANA STRATA.		FROM TERTIARY STRATA.		Total Production.
	Tons.	*Per cent. of total.*	Tons.	*Per cent. of total.*	Tons.
1914 . .	16,039,261	*97·42*	425,002	*2·58*	**16,464,263**
1915 . .	16,673,237	*97·48*	430,695	*2·52*	**17,103,932**
1916 . .	16,863,466	*97·74*	390,843	*2·26*	**17,254,309**
1917 . .	17,814,524	*97·81*	398,394	*2·19*	**18,212,918**
1918 . .	20,322,892	*98·08*	399,601	*1·92*	**20,722,493**
Average .	*17,542,676*	*97·70*	*408,907*	*2·30*	**17,951,583**

The Gondwana coal fields.

During the preceding quinquennial period the contribution from the Gondwana coalfields rose from 97 to nearly 97·6 per cent. of the Indian total. During the period now under review this percentage rose to 98·08, owing to great activity in Bengal and Bihar, and especially to the rapid development of the Jharia coalfield. When the Review of Mineral Production was issued in 1903, the Raniganj field was still the leading field in India, and it maintained its lead up to the year 1905. In 1906, however, Jharia outstripped Raniganj, and in subsequent years has steadily increased its lead, until it now produces more than half of the total production of India (see fig. 8, p. 45). The figures of production from the Gondwana coalfields are shown in table 21.

TABLE 21.—*Output of Gondwana Coalfields for the years 1914 to 1918.*

	1914.		1915.		1916.		1917.		1918.	
	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*
Bengal, Bihar and Orissa—										
Daltonganj . . .	81,680	*·50*	85,785	*·50*	76,298	*·44*	79,627	*·44*	81,816	*·39*
Giridih	825,026	*5·01*	872,647	*5·10*	866,055	*5·02*	824,007	*4·52*	846,592	*4·09*
Jainti	...	...	40,730	*·24*	75,089	*·44*	86,894	*·48*	140,373	*·68*
Jharia . . .	9,146,653	*55·55*	9,140,800	*53·44*	8,950,318	*51·87*	9,783,788	*53·72*	10,952,010	*52·85*
Bokaro	16,920	*·15*	10,232	*·06*	197,255	*1·14*	360,760	*1·98*	541,977	*2·62*
Rajmahal . . .	8,145									
Raniganj . . .	4,946,295	*30·04*	5,484,596	*32·07*	5,535,307	*32·09*	5,376,022	*29·52*	6,368,519	*30·74*
Sambalpur (Hingir-Rampur).	60,883	*·37*	58,825	*·34*	59,737	*·35*	52,892	*·29*	51,038	*·25*
Darjeeling . .	17	...	...	...	...	...	...	...	...	...
Central India—										
Umaria . . .	152,906	*·93*	139,680	*·82*	200,285	*1·16*	198,407	*1·09*	199,975	*·96*
Central Provinces—										
Ballarpur . . .	89,292	*·54*	94,880	*·56*	84,889	*·49*	95,303	*·52*	135,375	*·65*
Pench Valley . . .	95,679	*·58*	103,152	*·60*	154,548	*·9*	204,502	*1·12*	267,303	*1·29*
Mohpani . . .	59,774	*·37*	55,086	*·32*	48,395	*·28*	71,693	*·39*	78,792	*·38*
Hyderabad—										
Singareni . . .	555,991	*3·38*	586,824	*3·43*	615,290	*3·56*	690,629	*3·74*	659,122	*3·18*
TOTAL Gondwana beds	16,039,261	*97·42*	16,673,237	*97·48*	16,863,466	*97·74*	17,814,524	*97·81*	20,322,892	*98·08*

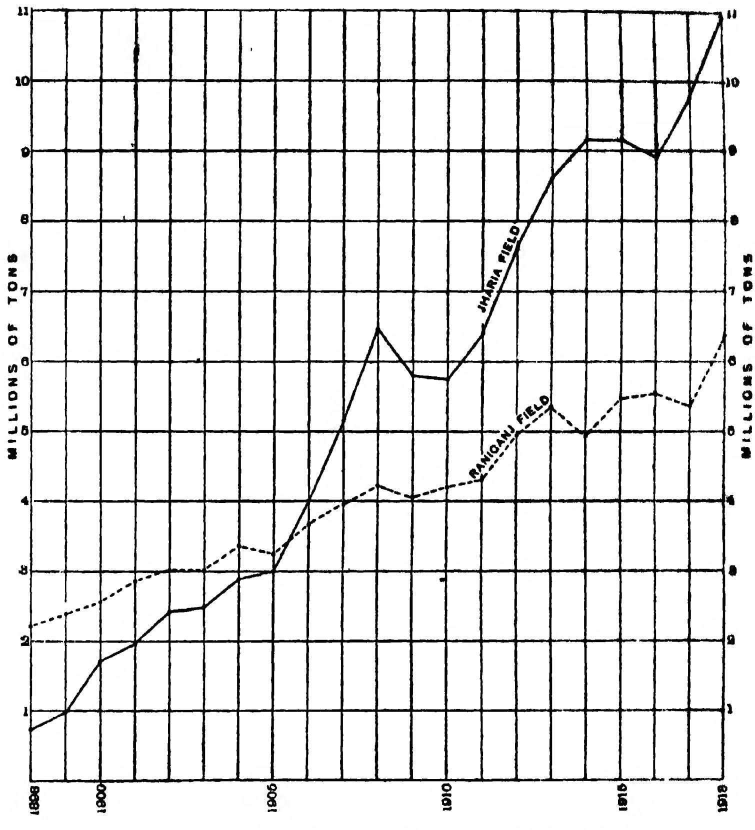


FIG. 8.—*Production of Coal in the Raniganj and Jharia fields, 1898-1918.*

Distribution of the Gondwana fields.

The Gondwana coals have been preserved on the eastern part of the Peninsula by being faulted down into the Archæan basement complex; but either the faulting or the softness of the Gondwana rocks has determined the direction of the Damuda, Mahanadi, and Godavari valleys in which the principal fields are found. In the Central Provinces the Gondwana rocks form the Mahadeva (or Mahadeo) Hills, a portion of the Satpura hill-range, which stands up above the general peneplain of the Peninsula.

The fields which have been worked to an appreciable extent include Raniganj and Jharia in the Damuda Valley; the Giridih

field occurring as a small isolated patch to the north of the Damuda Valley; the Daltonganj field, further west, in the Palamau district; the Singareni, Ballarpur, and Warora fields in the Godavari Valley; the Mohpani and Pench Valley fields lying respectively at the northern and southern fringes of the Satpura Range. Before the great depressions now occupied by the Indus, Ganges and Brahmaputra were formed, the Gondwanas probably stretched in great sheets of sandstones, shales and coals as far north as the area now occupied by the Outer Himalaya, and fragments of the strata caught up in the Himalayan folds are now preserved near Darjeeling, in Bhutan, and in North Assam. The coal in these extra-Peninsular patches of Gondwana rocks has been damaged by crushing, but prospecting operations in the Darjeeling district have shown that there is valuable fuel obtainable in this area.[1]

The north-western ends of the Godavari and Mahanadi belts of coalfields have been overwhelmed by the great sheets of Deccan trap, and no one knows, consequently, how much coal lies hidden under this mantle in the Central Provinces and Berar.

Raniganj field.

The Raniganj field covers an area of about 500 square miles, most of it within the civil district of Burdwan, but stretching also across the boundaries into Bankura, Manbhum, and the Santhal Parganas. The field was surveyed in 1858-60 by W. T. Blanford, and his map, published on a scale of one inch to a mile,[2] has been the recognised guide for colliery managers. Additional details regarding seams discovered during subsequent mining operations have been added by Dr. W. Saise and Mr. G. A. Stonier to a map published by the *Colliery Guardian*,[3] and a map was prepared, but not published, by Babu Baidyanath Saha showing the distribution of the dykes of basalt and mica-peridotite which traverse the field in great numbers. A few years ago a Committee of the Mining and Geological Institute of India was formed to undertake the revision of the geological map on a scale of four inches to a mile, and Mr. H. Walker of the Geological Survey was placed on special duty in order to compile the results obtainable from the mine-plans. Thanks to the strenuous assistance given by Mr. R. R. Simpson, Inspector of Mines, and to the willing co-operation of managing agents and

[1] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXIV, p. 212 (1891).
[2] With *Mem. Geol. Surv. Ind.*, Vol. III, Part I.
[3] Supplement: Feb. 10th, 1905, p. 21.

colliery managers, the work has been completed and the map published by the Mining and Geological Institute, which body is now undertaking a similar task in connection with the Jharia field.

The subdivisions of the Gondwanas represented on the field are :—

3. *Panchet.*
2. *Damuda* :—
   - *c.* Raniganj stage.
   - *b.* Ironstone shales.
   - *a.* Barakar stage
1. *Talchir.*

There is a general dip to the south and south-east throughout the field, and consequently the Talchirs are exposed as a band along the northern margin, succeeded by the younger formations towards the south. As the beds dipping to the south-east are overlapped by the alluvium of the Damuda valley, the distance to which the coal-bearing rocks extend in this direction towards Burdwan and Calcutta is unknown. In order to test the field in this direction a boring was put down by the East Indian Railway Company in the years 1903 to 1906 at Durgapur, 16 miles south-east of Raniganj, but to the depth of 3,000 feet the only rocks penetrated were those of the Panchet series and perhaps the upper part of the Raniganj stage. At this point, therefore, the coal-seams are buried to a greater depth than 3,000 feet. As the Damuda river stretches away to the south-east in an almost straight line for a distance of about 45 miles beyond the Raniganj field, and thus runs approximately parallel to some great faults within the field, it is possible that its alignment is determined by a great dip-fault, and the Gondwana strata possibly continue along the left bank of the river far beyond the visible limits of the field. Although the Durgapur boring shows that the coal-seams are at that point more than 3,000 feet below the surface, it is quite possible that the depressing effects of the general south-easterly dip may be neutralised by strike faults. Whether the coal measures are brought up in this way to within workable distance of the surface towards the south-east, or whether they are now hopelessly beyond reach (if they ever were developed in this area), can only be determined by trial borings to the south-east of Durgapur. So long as there are abundant supplies nearer the surface in the Raniganj and Jharia fields, it will be to no one's financial advantage to risk the money required to test this interesting question.

The information at present available for publication regarding the quality of the coal being worked in the Raniganj field is comparatively limited, for the correlation of the various seams being worked in the different collieries is still doubtful. We are indebted to Dr. W. Saise for a series of essays published in 1904.[1] These show the following extremes and averages :—

TABLE 22.—*Assays of Coal from the Raniganj Field (W. Saise).*

—		Moisture.	Ash.	Volatile Matter.	Fixed Carbon.
RANIGANJ (Upper Seams).	Highest	9·05	22·67	38·53	60·50
	Lowest	4·60	8·00	26·40	32·40
	Average of 11 assays	*6·86*	*14·93*	*32·22*	*45·99*
RANIGANJ (Lower Seams).	Highest	6·20	22·50	38·25	61·00
	Lowest	1·50	8·84	27·00	46·00
	Average of 28 assays	*3·81*	*13·54*	*31·40*	*51·25*
BARAKAR SEAMS.	Highest	1·50	25·00	29·25	61·00
	Lowest	0·50	11·00	23·75	49·00
	Average of 8 assays	*1·00*	*17·00*	*26·75*	*55·25*

With variations so wide among the samples these assays are too few to give reliable averages; but they show that the older Barakar seams differ consistently from those of the Raniganj stage in containing less moisture and generally also by having a smaller percentage of volatile hydrocarbons. This tendency was confirmed by the work of Lieutenant-Colonel F. C. Cunninghame Hughes who investigated the composition and calorific value of a number

[1] *Rec. Geol. Surv. Ind.*, XXXI, p. 104.

of samples from various Bengal and Bihar coalfields.[1] His results for the Raniganj field are summarised below[2] :—

—	Moisture per cent.	Volatile matter per cent.	Fixed carbon per cent.	Ash per cent.	Calorific value (in calories).
Raniganj or Upper Measures (average of 22 samples).	4·76	32·16	53·42	9·66	6,767
Barakar or Lower Measures (average of 8 samples).	1·65	24·76	64·05	9·54	7,348

Similar differences have been observed in the coal-seams of the Jharia field. The higher seams of the Raniganj stage also differ from those below by containing generally more moisture and volatile matter with less fixed carbon.

Jharia field.

In the Jharia field the only Gondwana formations preserved are the Talchirs and the three divisions of the Damuda series—the Barakar, Ironstone Shales, and Raniganj. The Barakars are by far the most important to the coal-miner, and no attempts were made to work the thinner and poorer seams of the Raniganj series until the 'boom' of 1906-08 led to the opening up of every tolerable seam of coal within range of the two railway systems that serve the field.

During 1903 a number of coal samples from the Barakar seams was taken by Messrs. E. P. Martin and H. Louis at the working faces in some leading mines in this field. The average of fifteen assays made on these samples was as follows :—

Fixed carbon .	63·50
Volatile matter	21·31
Ash . .	14·29
Moisture .	0·90

Ten of these were tested for sulphur and were found to contain on an average 0·57 per cent., while the same ten samples showed an average evaporative power of 12·82 lbs. of water per lb. of coal.

[1] *Trans. Min. Geol. Inst. of India*, V, p. 114 (1910).
[2] R. R. Simpson, *Mem. Geol. Surv. India*, XLI, p. 49 (1913).

Subsequently in 1909 assays made by Lieutenant-Colonel F. Cunninghame Hughes [1] gave similar results; these are summarised below [2]: —

—	Moisture per cent.	Volatile matter per cent.	Fixed carbon per cent.	Ash per cent.	Calorific value (in calories).
Raniganj or Upper Measures (2 samples).	1·68	30·61	57·26	10·45	7,195
Barakar or Lower Measures (22 samples).	1·25	23·21	63·77	11·78	7,197

The Jharia field, like those of Raniganj and Giridih, is traversed by trap-dykes, the most destructive being a peculiar form of mica-peridotite [3] which spreads out as sheets in the coal-seams, destroying large quantities of valuable coal. The seams known as 14 and 15, which otherwise include a high quality of coal, are especially damaged by trap intrusions in the centre and east of the field.

The Barakars form a crescent-shaped outcrop along the northern and eastern boundaries of the field, the seams of coal being numbered from the margin inwards from 1 to 18. Small faults occur in most parts of the field, but generally in the north and east there is little disturbance and the seams, which dip inwards at gentle angles to the south and west, can be followed with fair confidence; but the south-east corner is considerably faulted, the seams generally dip at greater angles, and the correlation of the seams worked in this area with those numbered in the rest of the field is often a matter of conjecture.

The field was first mapped and described by the late T. W. H. Hughes [*Mem. Geol. Surv. Ind.*, Vol. V, part 3 (1866)]. Certain additions and corrections were made after further examination by T. H. Ward in 1890 (*Rec. Geol. Surv. Ind.*, XXV, page 110), and Mr. Ward's map, with further additions by G. A. Stonier, was re-published by the *Colliery Guardian* in 1904 (Supplement, September 16th, page 5).

A large-scale map of the Jharia field on a scale of 4″=1 mile has now been completed by the Mining and Geological Institute

[1] *Trans. Min. Geol. Inst. India*, V, p. 114 (1910).
[2] R. R. Simpson, *Mem. Geol. Surv. India*, XLI, p. 54 (1913).
[3] T. H. Holland, *Rec. Geol. Surv. India*, XXVII, p. 129 (1894).

of India. The completion of this work is largely due to the efforts of Mr. R. R. Simpson. The geology was recently revised by Mr. G. de P. Cotter of the Geological Survey, who devoted much time and energy to what proved to be no easy task ; the incompleteness of the topography of the 4″ sheets and the disappearance of old boundary pillars rendered a new survey not infrequently necessary.

Immediately west of Jharia, on the other side of the Jamuni river lies the western termination of the Jharia field, now known as Bokaro-Jharia. West of this again is the Bokaro field to develope which the Bokaro-Ramgarh Colliery Company was formed a few years ago after obtaining mineral concessions from the Rajah of Padma.

Three large collieries are now at work in the Bokaro field, *viz.*,—the Joint East Indian and Bengal-Nagpur Railways colliery ; the Kargali colliery owned by the Great Indian Peninsula Railway and the Dhori colliery worked by Bokaro and Ramgur Ltd.

Bokaro field.[1]

The equipment of the first-named colliery is practically complete and the outturn in 1919 amounted to about 400,000 tons.

At the Kargali colliery, which adjoins the Joint Railway colliery on the east, little or no permanent machinery has been obtained owing to the war, but by purchasing temporary plant in the country a large amount of development has taken place and an output of 300,000 tons was obtained in 1919.

The Dhori colliery situated immediately to the East of Kargali has only recently been opened out and the first consignment of coal was despatched early in 1920.

The same seam of coal, *viz.*, the Kargali, is being worked at all three collieries and it varies in thickness from 75 feet on the east to 105 feet on the west. At the Dhori colliery it is found in two sections each about 37 feet in thickness with a dividing parting of 40 feet of hard sandstone. It produces a good hard blast-furnace coke.

Up to the present only one other seam has been proved in this area which is of any commercial value, namely "Ward's 12-foot seam", which actually contains about 8 feet of good coal. It is about equal in quality to the Kargali seam and is just being

[1] Kindly communicated by Mr. R. W. Church, Mining Engineer to the Railway Board.

opened out from the shafts being sunk by the Great Indian Peninsula Railway. This seam lies some 250 feet above the Kargali.

On the west side of the Kunar river large areas containing the Kargali seam have been proved lying in several cases at considerable depths. The thickness of the seam here appears to vary considerably and reaches a maximum of about 120 feet.

The joint East Indian and Bengal-Nagpur Railway line, known as the Bokaro-Ramgarh extension, is at present completed to within one mile of the east bank of the Kunar river and it is expected that work will shortly be commenced on the extension to the new areas on the western side of the river. The Joint East Indian and Bengal-Nagpur Railways have already commenced preliminary operations at Sawang on the opening out of another colliery in this western area. Thick seams of coal of fair quality have also been discovered in that portion of the field lying to the west of Lugu Hill.

Several of the Bokaro coals have been proved to be capable of producing good quality blast-furnace coke.

Ramgarh field.

The small field known as the Ramgarh field lies from 15 to 20 miles south-west of Bokaro. It is traversed by the Damuda river, in the bed of which the coal crops out in numerous places.

Other fields.

The other principal coalfields being worked in the Peninsula are Mohpani, the Pench Valley, and Ballarpur in the Central Provinces, Umaria in the Rewah State, and Singareni in the Nizam's Dominions. Of these Ballarpur was opened up to take the place of the Warora colliery, which was closed down in 1906.

Ballarpur.

In anticipation of the failure of Warora, prospecting operations were undertaken by Government at Ballarpur, 38 miles to the south-south-east in the Chanda district, on the left bank of the Wardha river. Coal was proved by borings over an area of 1½ square miles and a shaft was commenced. The large quantities of water met with in sinking proved to be a formidable obstacle, as all fuel used for the pumping engines had to be carried by road from Warora. Ballarpur was joined to the Great Indian Peninsula system by an extension of the Wardha-Warora branch, which was opened for traffic on the 1st February 1908. Meanwhile two 14-foot circular shafts had been sunk to the coal at depths of 257 feet (No. 1) and 236 feet (No. 2), and in

1906 a small quantity of coal was raised for use on the railway construction works. One of the shafts is lined with brick and ferro-concrete, and the other with fire-bricks moulded to the circle of the shaft. The colliery was ultimately sold to a private firm and was handed over on April 1st, 1913.

Ballarpur was the first colliery in India to adopt hydraulic stowage, which was introduced by the Manager, Mr. R. S. Davies, in March 1913. According to Mr. Davies, the seam at Ballarpur is 52 feet 6 inches thick. Two portions of it are workable. The upper portion is 24 feet 6 inches from the bottom of the seam and is 8 feet thick; the lower is the bottom part of the seam and is also 8 feet; this leaves 16 feet 6 inches between the workable portions, which, with the remaining upper 20 feet, are composed of shale and coal. To extract all or the greater part of the coal of these two workable sections, it was decided to work the upper portion first and to adopt hydraulic sand-packing to keep intact the roof, to prevent strata and surface water from flooding the mine, and as a preventive against fire.[1]

During the period under review, the output of Ballarpur rose from 89,292 tons in 1914 to 135,375 tons in 1918. The coal like most of that obtained from the Gondwanas of the Central Provinces contains a large proportion of moisture, and also shows inclusions of pyrites. The following two assays were made in the Geological Survey Laboratory on samples obtained when the seam was being first opened up:—

Moisture	11·10	13·51
Volatile matter	31·56	30·61
Fixed carbon	45·47	45·21
Ash	11·87	10·67
	100·00	100·00

The average number of persons employed daily at Ballarpur during the period 1914-18 was 1,085; there were six deaths during the period, the death-rate being 1·1 per 1,000.

The annual figures of persons employed are:—

1914	708 persons.
1915	833 ,,
1916	890 ,,
1917	1,192 ,,
1918	1,801 ,,

[1] *Trans. Min. Geol. Inst. India*, X, 53 (1916).

Pench Valley.[1]

In the year 1918 the output of the Pench Valley coalfield was 267,303 tons. Two collieries have been opened out by the Pench Valley Coal Company, Limited, and are served by the Bengal-Nagpur Railway:—(1) Barkui, (2) Buteria; while a third, Wallace Pit Colliery, also owned by this Company despatches its output over the Great Indian Peninsula Railway.

Collieries have also been opened out at Parasia for the Central Pench Coal Company, Limited, at Jatachappa for the Upper Pench Coal Company, Limited, at Bhajipani and Eklahra for the Pench River Coal Company, Limited. A further Colliery at Dongar Chickli is being opened out for the Central Pench Coal Company, Limited, and mining rights have been obtained for a colliery at Jamai for the Pench Consolidated Coal Company, Limited, and work will commence as soon as the price of machinery and other material becomes more normal. These collieries are all served by the Great Indian Peninsula Railway.

The average number of persons employed daily during the years 1914 to 1918 was 1,651. This with 15 deaths gives a death-rate of 1·8 per 1,000. The annual labour figures are:—

1914	1,240 persons.
1915	1,118 ,,
1916	1,477 ,,
1917	1,680 ,,
1918	2,740 ,,

Mohpani.

The oldest colliery in the Central Provinces is Mohpani. The Mohpani coalfield is situated in the Narsinghpur district on the south side of the Narbudda alluvial valley, and at the foot of the northern spurs of the Satpuras. The divisions of the Gondwana system exposed in this field are the Mahadevas, the Barakars, and the Talchirs, the known coal-seams lying, as usual, in the Barakars. About forty years ago, the Sitariva Coal Company carried out a certain amount of work on the field, but the actual development of the Mohpani coalfield is due to the efforts of the Nerbudda Coal and Iron Company, Ltd., which commenced operations in 1862, and, from then until 1904, spent more than £150,000 on the undertaking. The mines are divided into the old field and the new field. The *old field* was abandoned in 1902 after practically the whole of the coal workable

[1] Kindly communicated by Messrs. Shaw, Wallace & Co.

by the existing shafts had been won, the total amount so extracted being 450,845 tons, the deepest shaft being the Helen pit, 405 feet deep, and the number of coal-seams four.

The *new field*, forming part of a second concession adjoining the old field, was first opened up in 1892, and up to the end of 1903 the Company had raised 181,080 tons of coal and splint from the two upper coal-seams. As in the old workings on the Sitariva river, faulting and heavy water discharge were, in 1903, giving considerable trouble; so that, in order satisfactorily to work out the already proved coal, additional capital was necessary for hauling and pumping plant. This capital the shareholders of the Nerbudda Coal and Iron Company were unwilling to supply. On the other hand, the Great Indian Peninsula Railway Company, to whose system the mines are connected by a ten-mile branch line to Gadarwada, and who had been taking the output of the Mohpani collieries at a uniform rate of Rs. 6 a ton, was dissatisfied with the small output; consequently, after a report by Mr. R. R. Simpson the properties were sold to the Great Indian Peninsula Railway Company for £40,000 with effect from the 1st July 1904. Since then the output has increased rapidly; from 22,998 in 1905 it rose to an annual average of over 50,000 tons in the period 1909-13 and to as much as 78,792 tons in 1918.

In the course of his examination of the field, Mr. Simpson made estimates as to the quantity of coal still left to be extracted, and he came to the conclusion that the amount of coal and splint proved by the workings was 1,610,379 tons of coal in Nos. 1 and 2 seams and 411,076 tons of splint in No. 1 seam. In addition to these, he estimated that 725,081 tons could safely be assumed as obtainable from Nos. 3 and 4 seams, and that an additional quantity of 4,833,902 tons of coal could reasonably be assumed to be obtainable from seams Nos. 1 to 4 and the upper and lower seams of the 1895 area, together with 426,018 tons of splint from No. 1 seam. The grand total thus estimated to be available is 7,169,362 tons of coal and 837,094 tons of splint. In making these estimates, Mr. Simpson assumed an extraction of two-thirds of the coal worked. The thicknesses of the four seams are :—

No. 1 seam	11 feet of coal with an intermediate band of 6 feet of splint, the specific gravities of coal and splint averaging 1·48 and 1·70 respectively.
" 2 "	25 feet.
" 3 "	15 feet.
" 4 "	6½ feet.

In the 1895 area, the thicknesses are taken as—

Upper seam	18 feet,
Lower seams	9 feet,

the extraction assumed for this area being 50 per cent. In addition, it is considered possible that a considerable quantity of coal may eventually be found in the old field to the dip of the Helen pit at a considerable, but by no means unworkable, depth; but, to prove this, boring will be necessary.

While examining the field Mr. Simpson took ten average samples of coal from seams Nos. 1 and 2 and one sample of the splint in seam No. 1. In 1908, Mr. F. L. G. Simpson, who was then manager of the Mohpani collieries, took a series of twelve samples of coal representing all the four seams (one of them being of the splint) for the purposes of the Nagpur Exhibition. These samples were subjected to approximate analyses in the Geological Survey Laboratory. In table 23 below are given the extremes and means of these twenty-one analyses of coal and of two analyses[1] of splint; and also an average of thirty-nine assays of Bengal coal, taken from Mr. R. R. Simpson's report. Speaking generally, the coal is somewhat inferior to the average of Bengal coals. Mr. R. R. Simpson quotes figures for trials on the Great Indian Peninsula Railway showing the following values:—

Sanctoria (Bengal)	1·00
Singareni	1·18
Mohpani	1·32
Warora	1·57
Umaria	1·62

Sanctoria coal is distinctly superior to the average Bengal coal, and it can be taken that $1\frac{1}{4}$ tons of Mohpani coal are equal to one ton of average Bengal coal.

[1] Some of these, together with some ultimate analyses and coke assays of Mohpani coal by Mr. C. S. Fawcitt of Bangalore, and a complete analysis of ash from No. 1 bottom seam, also by Mr. Fawcitt, are given in the report (L. L. Fermor and J. Kellerschon) on the Mining Section of the Central Provinces Exhibition in *Trans. Min. Geol. Inst. Ind.*, IV, pp. 134 and 135 (1909).

TABLE 23.—*Assays of coal from the Mohpani field.*

—		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur	Calorific value in heat units (C).	Evaporative value in lbs. of water.
MR. R. R. SIMPSON'S SAMPLES (1904).	Highest .	4·60	32·04	57·54	35·98	...	...	...
	Lowest .	1·28	17·86	39·50	15·50	...	...	...
	Average of 10 assays.	*2·52*	*24·51*	*48·96*	*24·01*	...	...	...
	Splint .	2·84	21·02	37·90	38·24	...	...	...
MR. F. L. G. SIMPSON'S SAMPLES (1908).	Highest .	5·97	34·20	53·03	22·94	0·79	7,187	13·38
	Lowest .	4·06	25·65	43·96	9·79	0·23	5,573	10·38
	Average of 11 assays.	*5·28*	*29·81*	*48·34*	*16·57*	*0·37*	*6,427*	*11·97*
	Splint .	3·68	23·06	31·94	41·32	0·85	4,400	8·19
BENGAL COAL-FIELDS.	*Average of 39 assays.*	...	*31·30*	*53·70*	*15·00*	...	...	...

The average number of persons employed daily at Mohpani during the period under review was 1,307, the annual figures being as follows :—

1914	1,264
1915	1,220
1916	1,188
1917	1,357
1918	1,508
Average .	*1,307*

The number of deaths was five, giving an average annual death-rate for the period of 0·76 per 1,000.

Singareni. The great belt of Gondwana rocks, near the north-west end of which Warora is situated, stretches down the Godavari valley as far as Rajamundry, and at one or two places the equivalents of the coal-bearing Damuda series in Bengal are found cropping up from below the Upper Gondwana rocks. One of these occurrences near Yellandu in the

Nizam's Dominions forms the coalfield well known by the name of Singareni. The principal seam of coal, some 5 to 6 feet thick, being worked at the Singareni colliery, was discovered by the late Dr. W. King of the Geological Survey in 1872, but mining operations were not commenced until 1886, since when the output has risen to over 600,000 tons a year.

For the first time since this Review was inaugurated, coal-mining at Singareni has been accompanied by a smaller loss of life by accidents than in most Gondwana fields. Table 24 shows the death-rate on this field compared with the rate in Bengal. The average figure for the five years 1914 to 1918 is only 1·24 per thousand as compared with 1·27 in the Bengal coalfields. The rate was 2·05 at Singareni in the period 1909-13.

TABLE 24.—*Death-rate from accidents at Singareni compared with Bengal.*

	—	1914.	1915.	1916.	1917.	1918.	*Average.*
SINGARENI.	Number of persons employed.	10,141	11,302	11,299	11,566	11,582	*11,178*
	Deaths from accidents .	24	11	11	8	14	*13·6*
	Death-rate per 1,000 employed.	2·36	·97	·97	·69	1·21	*1·24*
Death-rate in Bengal coalfields .		*1·05*	*1·09*	*1·78*	*·9*	*1·53*	*1·27*

Umaria.

The Bilaspur-Katni branch of the Bengal-Nagpur Railway passes through the small coalfield of Umaria in the Rewah State, Central India. The quantity of workable coal in this field is estimated to be about 24,000,000 tons. During the periods of the two last reviews the average annual output fell to about 139,000 tons. During the period now under review the output has risen again, the annual average being over 178,000 tons (see table 21). The three coal-seams being worked vary from about 3 to 12 feet in thickness and dip at about 4° to the north-east. The mines were opened in 1882 under the direction of Mr. T. W. H. Hughes of the Geological Survey and were controlled by Government until the 1st January 1900, when they were handed over to the Rewah State, to which they are a source of considerable

profit, the annual net earnings during the period 1909-13 amounting to about Rs. 2,50,000[1]; in the year 1908-09 the earnings amounted to about Rs. 1,50,000.

The average number of persons employed daily at Umaria during the period under review was 2,339, the figures for each year being as follows :—

1914	3,038
1915	2,884
1916	1,480
1917	1,244
1918	3,047
Average	*2,339*

The number of deaths was four giving the low average death-rate for the period of 0·34 per 1,000 employed.

Korea.

In 1913 a geological examination was made of the coalfields of Korea State in the Central Provinces.[2] The northern or Sanhat field contains two principal seams the lower of which is valueless in the western half of its course, but shows thicknesses of 4 to 9 feet over a length of 16 miles in the eastern part of the field. The upper seam is valueless in the east, but ranges from 3½ feet to nearly 10 feet in the west. The result of a considerable number of assays shows that neither seam is of good quality, the ash content ranging from 15·38 per cent. to 32·24 per cent. in the case of the lower seam and from 22·98 to 36·68 per cent. in the case of the upper. In the Kurasia section of the Kurasia field 6 coal horizons were found, in one of which (horizon 4) there are from 2 to 5 seams, ranging in thickness from 1 foot to 8 feet 6 inches. This horizon is supposed to cover about 4 square miles, in which case an average thickness of the coal of, say, 5 feet would correspond to 5½ million tons per square mile. This, however, must still be proved by boring. Numerous samples taken show that the coal of this area is better than that of the Sanhat field, the ash content ranging from 9·32 per cent. to 13·82 per cent.; the average composition of all the samples taken is shown below.

Still better coal is found in the Chirmiri section of the Kurasia field, where the finest seam of coal in the State is exposed in the

[1] Figures for 1914-15 to 1918-19 are not available.
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XLI, pt. 2.

Kauria stream at and below a waterfall known as the Karar Khoh. Seven seams, aggregating 38 feet in thickness, were observed, the average assay value being shown in the following table :—

Table 25.—*Assays of Coal from Korea State.*

—	Sanhat field.		Kurasia field (Horizon 4).	
	Seam No. 1 (Lower).	Seam No. 2 (Upper).	Kurasia area.	Chirmiri area (Kauria Nala).
Number of analyses	3	5	6	10
Moisture	5·79	4·19	8·66	7·94
Volatile matter	28·22	24·00	30·92	29·68
Fixed carbon	44·80	44·00	48·86	51·20
Ash	21·19	27·81	11·56	11·18
	100·00	100·00	100·00	100·00

This series of seams appears to thin out gradually in all directions: but it is considered that there are from 1 to 1½, possibly even 2, square miles, over which the coal is at least 10 feet thick. It is estimated, therefore, that at least 7 million tons of good coal are available, possibly a considerably larger quantity. The dip of the seams is always very low, usually almost horizontal.

Bhutan.

In the foot-hills of Bhutan[1] coal has been found near the Kala Pani as highly-inclined crushed lenticular seams near the junction of the enclosing Gondwana rocks with the Siwaliks; which is marked by a reversed fault. The coal is of poor quality, friable, and does not seem to occur in any large quantity, the total length of outcrop at the principal locality being 900 feet, and the average total thickness not more than 12 feet.

By-product coking.

It is now over ten years since the first by-product coke plant was installed in the Indian coalfields; this consisted of 18 Simon Carvès ovens which

[1] G. E. Pilgrim, *Rec. Geol. Ind.*, XXXIV, pp. 31—36 (1916).

were erected at the East Indian Railway Company's collieries at Giridih. Subsequently, a second battery of 12 ovens was added, and the two batteries are now producing annually about 42,000 tons of coke, 500 tons of sulphate of ammonia; and 1,400 tons of tar. The tar is said to be of very good quality and to find a ready sale throughout India. The sulphuric acid used is manufactured at Giridih by Messrs. D. Waldie and Co. in the acid chambers erected for the purpose close to the coke ovens.[1]

The East Indian Railway Company's example has been followed by several other companies, and during the period under review, by-product ovens were installed at the Tata Iron and Steel Company's works at Jamshedpur (50 Coppée ovens), at the Bengal Iron Company's works at Kulti (64 Simon Carvès ovens), and at Lodna colliery in the Jharia field (30 Simon Carvès ovens). The total output of the plants working on the coalfields[2] in 1918 was about 180,000 tons of coke, 4,800 tons of tar, and 2,000 tons of sulphate of ammonia. In all cases, sulphuric acid is manufactured on the spot from imported sulphur. Other plants are at present (1919) in course of erection, and one (a battery of Koppers ovens at Loyabad colliery) was completed after the end of the period under review. The extension of by-product coking, however, is limited by the market for the articles produced. Unfortunately, the demand for hard coke in India is at present a limited one, and the ovens now at work are more than sufficient to meet it. The by-products (tar and sulphate), however, always find a sale.

Tertiary Coalfields.

As has already been noted (see page 42), all the coal being worked outside the Gondwana coalfields is of Tertiary age. Coal of this age is found in Baluchistan, Sind, Rajputana, the Punjab, along the foot-hills of the Himalaya, further east in Assam, in Burma, and in the Andaman and Nicobar Islands. The most frequent occurrence is in association with nummulitic limestones (Eocene), although the richest deposits, *viz.*, those in North-eastern Assam, are younger, probably Miocene. The output from each of these Tertiary fields for the years 1914 to 1918 is shown in table 26. From this table it will be seen that the output of Tertiary coal

[1] Information kindly brought up to date by Mr. A. Wright, Acting Colliery Superintendent, East Indian Railway Co.'s Collieries, Giridih.
[2] *i.e.*, excluding the Jamshedpur installation.

during the period under review averages a little over 400,000 tons a year.

On the whole, the younger coals, which are being worked in extra-Peninsular areas, differ from the Gondwana coals in containing a larger portion of moisture and volatile hydrocarbons, and though as variable in composition as they are in thickness of seam, coals are obtained, as for instance in Assam, with a remarkably low percentage of ash and having a high calorific value. The high proportion of moisture in some of these younger coals is, however, often a serious cause of deficiency in calorific value. The difference between the Tertiary coals and Gondwana coal from Bengal is well seen in table 27, which gives the extremes and averages of analyses of five samples of coal from Assam, two from Baluchistan, one from Burma, and five from the Punjab, given in a paper on the "Composition and Quality of Indian Coals" by Professor W. R. Dunstan[1]; and also the average of thirty-nine samples of Bengal coal by Mr. R. R. Simpson, given on page 64.

North-eastern Assam.

The most promising amongst these young coals is the group of occurrences in North-eastern Assam, one of which is now being worked by the Assam Railways and Trading Company, which commenced operations at Makum (27° 15′; 95° 45′) in 1881. The collieries are connected by a metre-gauge railway with Dibrugarh on the Brahmaputra river, which, being navigable, forms both a market and a means of transport for the coal. The coal-bearing rocks to which the Makum field belongs stretch for 40 miles to the north-east, and can be traced for 100 miles to the south-west, along the northern front of the Patkai range. The most valuable seams occur between the Tirap and Namdang streams, where, for a distance of about 5 miles, the seams vary from 15 to 75 feet in thickness. Near Margherita, where the collieries are situated, the average thickness of the thickest seam now being worked is about 50 feet of coal, with intercalations of fire-clay amounting to 10 feet; in the Namdang section it increases to as much as 80 feet, and is persistent, with little variation, for a distance of 6 miles. The average dip is 40°; but as the outcrops in many places are several hundred feet above the plain, facilities exist for working the coal by adit

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 241-253 (1906). The results tabulated in this paper are supplementary to those given in the *Indian Agricultural Ledger* (No. 14, 1898), and *Journ. Soc. Arts*, L., pp. 371—407 (1902).

TABLE 26.—*Production of Tertiary Coal during the years 1914 to 1918.*

COALFIELD.	1914.		1915.		1916.		1917.		1918.	
	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*	Tons.	*Per cent. of Indian Total.*
Assam—										
Makum	303,890	*1·86*	308,071	*1·82*	283,830	*1·66*	291,484	*1·65*	267,749	*1·42*
Naga Hills	778		2,872		3,135		8,906		24,299	
Sibsagar	...		...		...		915		1,827	
Khasi and Jaintia Hills	492		353		350		175		609	
Baluchistan—										
Khost	39,557	*·24*	35,782	*·21*	32,995	*·19*	29,517	*·22*	29,600	*·21*
Sor Range, Mach, etc.	8,677	*·05*	7,825	*·05*	9,168	*·05*	11,268		13,525	
Burma—										
Bhamo	...	...	25	...	...	...	...	...	...	...
North-West Frontier Province—										
Hazara	94	*·33*	60	*·34*	75	*·28*	215	*·29*	240	*·24*
Punjab—										
Jhelum	45,867		51,613		44,944		40,322		39,651	
Mianwali	1,557		2,029		817		2,916		5,152	
Shahpur	6,879		4,269		1,688		6,631		5,615	
Rajputana—										
Bikanir	17,211	*·10*	17,796	*·10*	13,841	*·08*	6,045	*·03*	11,334	*·05*
TOTAL (Tertiary Beds)	**425,002**	*2·58*	**430,695**	*2·52*	**390,843**	*2·26*	**398,394**	*2·19*	**399,601**	*1·92*

TABLE 27.—*Average Assays of Tertiary and Gondwana (Bengal) Coals.*

—		Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Calorific value in heat units (C).	Evaporative value in lbs. of water.
Tertiary: higher grade: Assam and Baluchistan—	Highest	5·83	46·48	53·28	9·56	4·87	7,702	14·34
	Lowest	1·45	40·42	41·50	1·27	0·74	6,028	11·22
	Average of 7 assays.	*3·19*	*43·58*	*48·99*	*4·24*	*3·14*	*6,926*	*12·90*
Tertiary: lower grade: Burma and Punjab—	Highest	10·85	47·08	39·44	39·91	4·41	6,730	12·53
	Lowest	3·47	26·85	27·79	8·50	0·33	4,270	7·95
	Average of 6 assays.	*6·56*	*38·89*	*34·57*	*19·98*	*1·91*	*5,610*	*10·45*
Bengal coalfields	*Average of 39 assays.*	...	*31·30*	*53·70*	*15·00*	...	...	...

levels. The average coal production of the Makum mines during the last five years has been 291,005 tons a year, as compared with 292,934 tons during the preceding period. The coal has the reputation of being a good fuel, and forms an excellent, though sulphurous, coke. Mr. R. R. Simpson has sampled the coal-seams being worked in the Upper Ledo and Tikak mines in this field.[1]

The average compositions given by three samples from the Upper Ledo colliery and representing an aggregate thickness of 49 feet, and five samples from the Tikak colliery representing an aggregate thickness of 47 feet, are shown below :—

	Upper Ledo.	Tikak.
Moisture	1·80	2·09
Volatile hydrocarbons	40·15	37·25
Fixed carbon	55·59	58·99
Ash	2·46	1·67
TOTAL	100·00	100·00

[1] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 239-241 (1906).

Mr. Simpson[1] has also examined the Jaipur and Nazira coal-fields lying to the south-west of the Makum field. Of these the latter is now being opened up. He confirms the estimate previously made by Mr. Mallett with regard to the large quantity of good fuel in these two fields; in addition to the estimates of coal that can be proved, there is the probability of larger quantities hidden by the alluvial deposits; but in many places the seams are highly inclined, and, being below the level of permanent saturation, will be difficult to work except with special precautions to deal with the water. The most promising of these propositions is the so-called *Nazira* field on the left bank of the Dikhu river. The seams are now being opened up and an aerial rope-way carries the coal to the railway. The quality of the coals from these fields is shown by a series of analyses[2] which are summarised below. The sulphur in five of the Jaipur coals averaged 1·87 per cent., and in five of the Nazira coals 3·35 per cent.

Coal of excellent quality also occurs in the Namchik valley, a tributary on the left bank of the Dihing River, three days' journey above Margherita. The locality, which, although only 18 miles in a straight line from Ledo, is difficult of access, was examined by Dr. E. H. Pascoe in 1911. Five groups of seams were noticed, with a total thickness of about 60 feet of coal.[3]

TABLE 28.—*Assays of Coal from the Jaipur and Nazira coalfields.*

——		Moisture.	Volatile matter.	Fixed carbon.	Ash.
Jaipur Field	Highest . . .	10·31	45·10	53·71	18·18
	Lowest . . .	3·95	35·49	41·38	1·10
	Average of 25 assays	*6·42*	*39·80*	*48·78*	*4·82*
Nazira Field	Highest . . .	7·23	42·90	54·64	14·45
	Lowest . . .	3·89	34·36	45·49	2·22
	Average of 12 assays	*5·49*	*38·11*	*50·04*	*6·36*

[1] *Rec. Geol. Surv. Ind.*, XXXIV, pp. 199-238 (1906).
[2] *Loc. cit.*, pp. 227—230.
[3] *Rec. Geol. Surv. Ind.*, XLI, p. 214 (1912).

Burma.

Coal occurs in various parts of Burma, but the only district from which there has been any regular output is Shwebo from which there were returns varying between 6,975 and 13,302 tons during the period 1898-1903. In February 1904, with the closing of the Lethobin mines, however, this district ceased to be a producer, and since that year the only output from Burma has consisted of small quantities extracted during prospecting operations.

Accounts have been published of the previously known fields near Lashio[1] and Namma and of two fields near Mansang and Man-se-le,[2] Pauk in Pakokku district[3] and Kawmapyin in the Tenasserim valley in Mergui.[4]

The four first-named fields are situated in the Northern Shan States; they form an isolated basin lying on the prevalent Plateau limestones, and consist of sand, shale, and lignitic coal, probably of Pliocene age. In all these fields the coal is lignitic, containing large quantities of moisture (10 to 23 per cent.), very low percentages of fixed carbon (9 to 40 per cent.), with very variable, often very high, quantities of ash. The best lignite seems to be that of the Namma field, but the cost of mining, briquetting, and transport of this fuel has hitherto been more than its value. Attention, however, has recently been drawn to the possibilities of lignite for use in the pulverised form and the Namma field is being re-examined by a local metal-mining company. It is said that the reserves in this field are very large.

At Wetwin in the Northern Shan States, 9 miles in a direct line to the east of the Lashio branch of the Burma Railways at Wetwin station, there is a deposit of lignite similar apparently to others found in the Northern Shan States. Mr. Coggin Brown, who examined it, was unable to determine its real stratigraphical position or to decide whether it belonged to the carbonaceous shales interbedded with the (Devonian) Plateau Limestone, or to the more common Tertiary lignite of Upper Burma; in appearance and

[1] T. D. LaTouche and R. R. Simpson, *Rec. Geol. Surv. Ind.*, XXXIII, pp. 117—124 (1903).
[2] R. R. Simpson *Rec. Geol. Surv. Ind.*, XXXIII, pp. 125—156; see also pp. 86—88.
[3] G. L. P Cotter, *Rec. Geol. Surv. Ind.*, XLIV, 163 (1914).
[4] P.N. Bose, *Rec. Geol. Surv. Ind.*, XXVI, 148 (1893).

character it resembles the latter. Three carefully sampled lots of the material gave the following results on analysis :—

Sample No.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Colour of ash.	REMARKS.
1	17·44	37·84	33·56	11·6	Brown	Does not cake.
2	16·94	39·19	34·43	9·44	Do.	Do.
3	14·80	38·10	32·78	14·32	Buff	Do.

Prospecting operations have not yet been carried out to determine the amount of coal available since other conditions at present do not seem to warrant any heavy expenditure on boring operations.

Coal has long been known to occur also in the Henzada district, but the prospects of successful exploitation are doubtful. The chief outcrops are at Posugyi, Kywezin, Hlemauk and Kyibin. Of these Kywezin seems to be the only area worth further attention; the coal there is very friable and greatly crushed, whilst the seam, which is about 10 feet thick, is much contorted; otherwise, its quality is good. Further north a coal-bearing belt of Tertiary rocks has been found to extend throughout the length of the Arakan Yoma at least from the Pakokku district southwards. Near the Yaw river seams of considerable local thickness were observed by Mr. G. de P. Cotter in the course of his systematic survey operations, and in the year 1914 he opened up and examined several of them. He divided the seams into three groups[1] :—

"(1) Those running from the Yaw river half a mile S.E. of Letpanhla village in a S.W. direction to the crest of the Pondaung fold. The dip varies between 40° at the Yaw river to close on 30° near the crest of the fold.

(2) The seams running from the crest of the Pondaung fold in Yekyin Chaung, north-westwards past Tazu village along the western flank of the anticline. All this coal dips steeply, and is usually inclined at angles of over 60°. It is much sheared and compressed.

(3) The seams exposed in the gently dipping western flank of the syncline west of Tazu village. The dip varies from about 10° in the north to about 20° in the south."

[1] *Rec. Geol. Surv., India*, XLIV, 163 (1914).

In the first area Mr. Cotter found 13 feet of coal in 28 feet of strata, the two best seams together giving a thickness of 6 feet 7 inches of available coal. The dip is about 30°. Shaly partings are very numerous. The coal of the best seams is a lignite containing between 17 and 19 per cent. of moisture and nearly 10 per cent. of ash.

Seams of the second group were too poor to warrant close examination.

Seams of the third group close to Tazu are mostly thin.

The annexed table shows analyses of 22 samples from Letpanhla.

No. of sample.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	REMARKS.
1	17·67	36·89	33·60	11·84	Sulphur—2·285% Calorific power: 4,820 heat units.
2	17·85	35·65	35·90	10·60	
3	17·07	35·39	34·90	12·64	
4	17·38	35·04	37·98	9·60	
5	18·64	33·46	37·92	9·98	
6	15·63	33·37	29·32	21·68	
7	17·30	34·02	36·02	12·66	Sulphur—3·983% Calorific power: 4,517 heat units.
8	19·42	32·06	33·16	15·36	
9	19·68	34·38	37·38	8·56	Sulphur=2·138% Calorific power: 4,663 heat units.
10	18·04	35·20	36·98	9·78	
11	19·22	34·38	37·04	9·36	Sulphur=2·638% Calorific power: 4,784 heat units.
12	15·92	37·36	35·22	11·50	
13	20·76	33·48	36·20	9·56	Sulphur—2·778% Calorific power: 4,499 heat units.
14	21·60	32·54	36·96	8·90	
15	21·19	32·51	34·04	12·26	
16	18·98	36·52	34·44	10·06	Sulphur=4·399% Calorific power: 4,519 heat units.
17	21·33	34·73	35·22	8·72	
18	20·28	31·74	39·26	8·72	Sulphur=4·782% Calorific power: 4,835 heat units.
19	18·54	32·12	36·60	12·74	
20	18·02	35·06	39·64	7·28	
21	19·82	31·98	37·54	10·66	Sulphur=5·628% Calorific power: 4,510 heat units.
22	16·94	33·00	33·18	16·88	

The high percentages of moisture and sulphur detract largely from the value of this coal. Mr. Cotter's conclusions are that:—

"(1) The seams are marred by frequent partings, making them expensive to work.

(2) The roof is poor, and would require expensive timbering.

(3) The quality of the coal is very poor owing to the high percentage of moisture, the small amount of fixed carbon, and the presence of excessive sulphur.

(4) It is not near any railway and is 46 miles distant from the [Irrawaddy] river."

Similar seams have been found at intervals along the eastern flanks of the Arakan Yoma, but indications are not, as a rule, sufficiently good to attract prospectors. A certain amount of attention, however, has recently been drawn to outcrops found in the foot-hills to the west of Minbu. It was stated that locomotive trials on a bulk sample had shown the coal to be not greatly inferior to Bengal steam coal. Mr. K. A. K. Hallowes examined the seams in the last year of the period under review. He found them to be thin, inconstant and of poor quality, containing between 13 and 26 per cent. of moisture and from 14 to 30 per cent. of ash. They were found to be typical of most of the lignite occurring in this belt and to be merely small lenticular patches extending, as a rule, for only a few hundred feet. Hopes raised by the locomotive trials proved to be illusory and the so-called bulk sample to have been a carefully hand-picked specimen representing merely a band of 2 or 3 inches of fairly pure lignite occurring in the middle of a seam of inferior quality.

Coal of Tertiary age occurs in the hills to the west of the Chindwin above Kalewa. A report by Dr. F. Noetling of the Geological Survey was published by the Government of Burma in 1893 and indicated the existence of a considerable amount of coal of very fair quality within easy reach of the river.

Baluchistan : Khost.[1]

Possibly the most important of the coal deposits in the west occur in Baluchistan, where, however, the disturbed state of the rocks renders mining operations difficult, expensive, and often dangerous. Besides the small mines in the Sor range, south-west of Quetta, and in the Bolan pass at Mach, collieries have been worked since 1877 at Khost (30° 12′ ; 67° 40′) on the Sind-Pishin Railway. The two seams being worked have an average thickness respectively of 26 and 27 inches. During the period of the preceding review, the output averaged

[1] An account of these mines, written by the manager, Mr. A. Mort, will be found in *Trans. Min. Geol. Inst. India*, VII, p. 295 (1913).

43,448 tons per annum, but during the quinquennial period 1914-18, it decreased considerably, the average being 33,490 tons per annum; this consists mainly of steam and dust coal, with a small proportion of nut; most of the dust coal is converted into pressed fuel, the quantity so manufactured averaging about 20,000 tons a year; this is sold at Rs. 12 to Rs. 17 per ton, the price of the steam coal being Rs. 10-8 to Rs. 18-2.

During the latter part of the period under review, work was carried on at a loss at these collieries, which are under the control of the North-Western State Railway. This loss, however, was inconsiderable (see table 29). The output per person employed at Khost averaged only 42 tons per annum during the period under review, and although the death-rate (4·29 per thousand) is much less than in the period previously reviewed (6·4 per thousand), it is still abnormally high.

Besides the stratigraphical difficulties arising from working Tertiary coal-seams, which are often irregular in thickness and lie in disturbed, uncertain ground, there are additional dangers due to the liability of most of these pyritous coals to spontaneous combustion, and to the danger of explosion by the large quantities of dust generally formed in working such friable coals. To these natural difficulties is added a serious scarcity of trained labour.

TABLE 29.—*Summary of the financial results of working the Khost Colliery during the years 1913-14 to 1917-18.*

Years.	Gross earnings.	Working expenses.	FINANCIAL RESULT.	
			Net earnings.	*Percentage on capital.*
	£	£	£	
1913-14	21,646	21,317	329	*1·99*
1914-15	20,037	19,367	670	*4·54*
1915-16	16,813	19,941	—3,128	...
1916-17	17,264	18,864	—1,600	...
1917-18	15,631	17,856	—2,225	...

Punjab : Dandot.

The coal that has been most worked in the Punjab is that long known to exist in the Jhelum district, on the Dandot plateau of the Salt Range. The only available seam varies in thickness from 18 to 39 inches, forming a basin under the nummulitic limestone. The mines at Dandot and at Pidh, 3 miles to the north-east, were worked for the North-Western Railway Company from 1884 till 1912, when it was decided to close work and sell the mines and plant as a going concern. These were purchased by Messrs. Thakur Dass and Ramji Dass, who have worked the mines since June 1912. During the period under review the output has risen considerably to just under 44,500 tons per annum as against 37,420 tons in the preceding quinquennium. This rise is no doubt due to some extent to scarcity of wagons and consequent restriction of imports of Bengal coal into North-West India. The annual output per miner employed at Dandot during the last five years has averaged only 45·5 tons against about 109 tons turned out per man in Bengal; the loss of life through accidents was slightly lower than in 1909-13, being 2·05 per 1,000 people employed as against 2·3.

Punjab : Shahpur district.

Coal-seams, similar to those of Dandot and Bhaganwala in the Jhelum district, are known to occur further west in the Shahpur district, the principal localities being Tejuwala near the crest of the southern scarp of the Salt Range, 12½ miles slightly west of north from Dhak on the Sind-Sagar branch of the North-Western Railway, and at Jhakarkot, 3½ miles south-west of Tejuwala. A small amount of work was prosecuted in 1890, but abandoned after the extraction of a few hundred tons of coal. Work was commenced on these deposits by Messrs. Bhagwan Das and Ram Das in 1905, and, during the three succeeding years, some 40,000 tons of coal were won. During the period under review, the average annual output of the Shahpur field has been a little over 5,000 tons, an increase of nearly 100 per cent. on that of the preceding period.

Punjab : Dilwal borings.

In order to ascertain whether there was any likelihood of a coalfield of any extent being hidden beneath the Salt Range plateau to the north of the Dandot-Nurpur scarp, borings were put down, during the years 1910 and 1911, near Dandot and also on the Dilwal plateau at the villages of Tothral and Arar, which lie some

considerable distance back from the scarp. In all cases the results were unpromising; near Dandot the seam was met with at 309 feet below the surface, but was only 1 foot 10 inches thick; at Tothral the seam was thinner still (1 foot 4 inches), while at Arar no coal was met with in the boring. It is not probable therefore that coal of any value lies beneath the limestone cover in that part of the Salt Range.

Rajputana : Palana.

Mining operations on the lignite of Palana in Bikanir State, Rajputana (see page 42), were begun in 1898 at a point where the seam was found to be 20 feet thick, and a branch line, 10 miles long, to the Jodhpur-Bikanir Railway, was constructed for the systematic development of the colliery. On account of the uncertainty regarding the horizontal extension of the seam, the output is restricted. The returns for the earlier periods show a steady fall in output from 45,078 tons in 1904 to 11,449 tons in 1909; there was then a small rise to 18,781 tons in 1913, while in the period under review the output fell to a little over 6,000 tons in 1917, but rose again in the following year to over 11,000 tons, but the average annual output for the five years 1914-18 was only 13,245 tons. The physical characters of the natural fuel form a drawback to its use in locomotives; but during December 1908 and January 1909, trials were made with briquettes manufactured in Germany from Palana coal and proved that the coal in briquette form would be suitable for locomotive work.[1] The proportion of moisture is reduced, and the fuel made less susceptible to atmospheric action. Briquetting p ant cannot, however, be erected until the coal output at the mines has been increased.

Labour.

Coal-mining, from the point of view of labour, still remains by far the most important of all forms of mining in India. During the period under review the average number of persons employed daily was 165,322, being on the average 39,460 higher than the figure for the preceding quinquennium. The rise in the amount of coal produced, however, was more than commensurate with the increased numbers and gives evidence of greater efficiency in the mining methods employed. The provincial distribution of labour is shown

[1] W. H. Phillips, 'The Manufacture of Patent Fuel,' etc., *Trans. Min. Geol. Inst India*, VI, p. 43 (1911).

in table 30, from which it will be seen that the share taken by the Bengal and Bihar coalfields has again increased slightly, over 86·18 per cent. of the Indian colliery workers being employed in those provinces in the period under review as against 86·01 in the preceding period.

Efficiency of the Indian collier.

Attention has been directed in previous reviews to the low efficiency of the Indian coal-miner compared with that of the collier in most other countries. Part of this apparent low efficiency has been due to the simplicity of the shallow mining operations, permitting the use of simple cheap labour with little machinery.

TABLE 30.—*Number of persons employed in the Indian Coal-Mining Industry during the years 1914 to 1918.*

PROVINCE.	1914.	1915.	1916.	1917.	1918.	*Average.*	Per cent. of average total.
Assam . . .	2,888	2,909	2,814	2,952	3,085	*2,930*	1·77
Baluchistan . .	1,001	963	1,111	955	993	*1,005*	·61
Bengal . . .	38,882	42,093	43,040	38,585	46,149	*41,750*	25·25
Bihar and Orissa .	90,855	95,292	92,053	106 571	118,849	*100,724*	60·93
Burma . . .	...	16	...	...	...	...	...
Central India .	3,038	2,884	1,480	1,244	3,047	*2,339*	1·41
,, Provinces .	3,254	3,184	3,558	4,245	6,052	*4,059*	2·46
Hyderabad . .	10,141	11,302	11,299	11,566	11,582	*11,178*	6·76
North-West Frontier Province.	7	9	7	14	12	*10*	...
Punjab . . .	1,161	1,273	1,049	1,033	1,358	*1,175*	·71
Rajputana (Bikanir)	149	161	143	107	198	*152*	·1
TOTAL .	**151,376**	**160,086**	**156,554**	**167,272**	**191,325**	*165,322*	100·00

The strings of coolie women carrying out coal along the inclines formed the most prominent feature of the fields in the old days. These are now naturally giving way to well-equipped installations

for haulage, both through inclines and shafts. Table 31 shows that while there has been a slightly greater output per person employed during the past quinquennial period than that shown by the returns of previous periods, the maximum efficiency during the past five years was lower than that for either 1912 or 1913. The apparent lack of improvement is partly due to the increased number of workers employed at the surface. The increased use of machinery with the deepening and extension of the mines shows up more distinctly in table 32, which gives the output of coal per person employed below ground. During the past five years the average annual output was 168·3 tons per person employed below ground as against 164·2 in the preceding quinquennium.

TABLE 31.—*Output of Coal per person employed at Indian Mines during the years 1914 to 1918.*

YEAR.	Average daily attendance of workers.	Output.	*Output per person employed.*
		Tons.	Tons.
1914	151,376	16,464,263	108·8
1915	160,086	17,103,932	106·8
1916	156,554	17,254,309	110·2
1917	167,272	18,212,918	108·9
1918	191,325	20,722,493	108·3

TABLE 32.—*Output of Coal per person employed below ground during the years 1914 to 1918.*

YEAR.	Average number of persons employed daily below ground.	Output.	*Output per person employed below ground.*
		Tons.	Tons.
1914	98,738	16,464,263	*166·7*
1915	106,772	17,103,932	*160·2*
1916	101,871	17,254,309	*169·3*
1917	104,948	18,212,918	*173·5*
1918	120,653	20,722,493	*171·8*

Table 33 shows how the efficiency of the Indian worker compares with that of the collier in other parts of the British Empire; but it should be remembered that this is not a true index of personal efficiency; in countries where labour is more expensive, and where mining operations are necessarily conducted at greater depths, the use of machinery becomes imperative, but it is instructive to note the much higher efficiency rate prevailing in Natal.

TABLE 33.—*Amount of Coal raised per person employed at Coal Mines in the British Empire.*

—	1914.			1915.		
	Persons employed.	Amount of coal raised in 1,000 tons.	Tons per person.	Persons employed.	Amount of coal raised in 1,000 tons.	Tons per person.
United Kingdom .	1,116,648	265,664	238	953,642	253,206	266
Canada . . .	27,359	12,176	445	24,574	11,794	480
Australia . .	24,286	12,445	512	22,143	11,415	516
New Zealand . .	4,734	2,276	481	4,156	2,209	531
Cape of Good Hope .	821	48	58	656	42	64
Natal . . .	10,100	2,293	227	9,281	2,057	222
Orange Free State .	1,932	624	323	1,982	650	328
Transvaal . .	10,315	4,605	446	10,357	4,645	449
British Empire, except India.	**1,196,195**	**300,131**	**251**	**1,026,791**	**286,018**	**278**
India . . .	151,376	16,464	108	160,086	17,104	106

We are indebted to the officers of the Department of Mines for the following note[1] on the use of electricity and coal-cutting machinery in the Bengal Coal Mines :—

"The prophecy in the last 'Review,' that the electrification of the majority of our large mines was only a question of time, has been realised.

[1] Revised by Mr. H. Lancaster, Inspector of Mines in India.

Use of electricity.

"Prior to the war there were approximately a dozen plants in the Jharia and Raniganj coal-fields supplying power to individual collieries or one or two mines situated close together. During the war two more plants were added to this list, and in addition two central power stations for supplying power to large groups of collieries were erected and actually working before the close of the war. These installations, in every instance, replaced wasteful steam plants, supplying power for pumping, winding, haulage and ventilation purposes, and have given most satisfactory results. At the present time the larger schemes which were contemplated during the war have developed, and the linking up of large groups of collieries to central power stations is being carried out. This has necessitated the scrapping of many of the original plants at individual collieries. There is no doubt, whatsoever, that the installation of electrically driven pumps and haulages at mines has been the means of increasing the output very considerably. Many collieries which in former years were water-logged during the rains can now be worked continuously. In the Jharia coal-field especially, owing to goafing operations, the quantity of water at many mines has been practically doubled, and it is only by means of electrically driven pumps that these large quantities of water can be dealt with successfully. The sinking of deep shafts through heavily watered strata in former years was considered impossible. With electrically driven sinking pumps this difficulty has disappeared. Electrically driven winding engines are at work at several mines and others are being erected; several of which will wind coal from shafts 1,500 feet in depth.

Coal-cutting machinery.

"Coal-cutting by machinery has now passed beyond the experimental stage. Chain machines of the Sullivan and Goodman types are being successfully worked and have been the means of increasing the output of the mines in which they are installed. In mines where sand-stowing has been adopted these machines have proved a great success. Percussive machines of various types are doing good work in developing the workings of new mines, and there is no doubt that when the Indian can be trained to manipulate them satisfactorily they will be universally used. As has been previously remarked, the adaptability of the Indian, when trained, to manipulate electrical machinery is most striking.

The advent of electrical power in mines has lessened the cost of production considerably, and when the larger schemes contemplated for the supply of power over extended areas have been installed, there is no doubt that costs will be still further reduced. Mines in India are so admirably adapted for the use of electrical power that one wonders why so much time has been lost and so much money expended in endeavouring to carry on under the old methods. Looking to the future it may be safely assumed that within a few years electricity will be the power in use at all important mines in British India."

Death-rate from accidents.

Attention has been directed in previous reviews to the low average death-rate from accidents in Indian coal-mines. The average annual death-rate per 1,000 persons employed during the years 1898 to 1903 was 0·88, varying between 0·68 (1898) and 1·32 (1899). During the next quinquennial period the rate was slightly higher, working out to 0·98 per 1,000 for all Indian coal mines, and varying between 0·72 in 1904 and 1·37 in 1908. Risks naturally increase with the deepening of the mines and general extension of the workings, while additional dangers may be incurred by the haste to increase production during periods of urgent demand for coal. There was a distinct rise in the average death-rate during the five years ending with 1913, the figure being 1·38 per thousand persons employed, but in the period under review there was again a considerable reduction to 1·14, the highest figure being 1·34 in 1916 and the lowest 1·02 in the following year.

TABLE 34.—*Production of coal compared with deaths from coal-mining accidents in India.*

——	1914.	1915.	1916.	1917.	1918.	*Average.*
Deaths from coal-mining accidents.	170	178	211	172	212	189
Thousands of tons of coal raised for each life lost.	97	96	82	106	98	96
Lives lost per million tons of coal raised.	10·6	10·5	12·4	9·5	10·6	10·7
Death-rate per thousand persons employed.	1·12	1·11	1·34	1·02	1·11	1·14

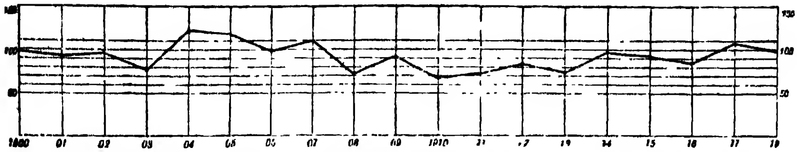


FIG. 9.—*Production of coal in thousands of tons per life lost by coal-mining accidents.*

The coal mines, like all other mines, in British territory are worked under rules framed in accordance with the provisions of the Indian Mines Act (No. VIII of 1901), and are subject to constant official inspection. The Inspectors are also invited at times to inspect the mines being worked in Indian States. During the period under review, the average annual number of deaths from accidents at coal mines in Indian States was 14·4 against 174 at mines in British India, the death-rate being 1·05 per thousand in the former case against 1·15 per thousand at the latter. The details for each year are given in table 35, from which it will be seen that, while there has been very little change in the labour returns at mines in Indian States, there has been a great increase of employment at mines in British India from a total of 138,048 in 1914 to 176,498 in 1918.

TABLE 35.—*Comparison of death-rate from accidents at coal mines in British India with those in Indian States during 1914 to 1918.*

YEAR.	AVERAGE NUMBER OF PERSONS EMPLOYED DAILY.		DEATHS FROM ACCIDENTS.		DEATH-RATE PER 1,000 PERSONS EMPLOYED.	
	British India.	*Indian States.*	British India.	*Indian States.*	British India.	*Indian States.*
1914 . .	138,048	*13,328*	145	*25*	1·05	*1·87*
1915 . .	145,739	*14,347*	166	*12*	1·14	*·83*
1916 . .	143,632	*12,922*	200	*11*	1·39	*·85*
1917 . .	154,355	*12,917*	163	*9*	1·06	*·69*
1918 . .	176,498	*14,827*	197	*15*	1·12	*1·01*
Average .	*151,654*	*13,668*	*174*	*14·4*	*1·15*	*1·05*

The returns for accidents at Indian coal mines are compared with those of the United Kingdom in table 36. The comparison is much less favourable to India than was the similar comparison for the years 1905 and 1906, given in an earlier Review. But the gradual change in mining conditions in India, from shallow

to deep, cannot but affect these statistics, and it is only owing to the vigilance of those employed in mining as well as to those employed in administering the Mines Act, that the death-rate is not higher than it is.

A comparison of the accident returns for India with those of the United Kingdom brings out the fact that, while our death-rate is low per thousand employed, it appears less favourable when we consider the lives lost in raising a million tons of coal. This is due obviously to our low output per person employed. During the past five years we have lost by accidents on an average 10·7 lives per million tons of coal raised, while for the United Kingdom the loss is about half this rate. Still, it is perhaps not unfair to judge the risks incurred in an industry by the relation between the loss of life and the numbers who secure a comfortable and, under Indian conditions, a fairly happy livelihood.

TABLE 36.—*Death-rate from coal mining accidents in the United Kingdom.*

	1914.	1915.	1916.	1917.	1918.
Number of persons employed	1,133,746	953,642	998,063	1,021,340	1,008,867
Number of deaths . .	1,219	1,297	1,313	1,370	1,401
Death-rate per 1,000 persons employed.	1·08	1·36	1·32	1·34	1·39
Deaths per 1,000,000 tons of Coal raised.	4·37	4·90	9·42	5·27	5·86

Copper.

[H. H. HAYDEN.]

Copper was formerly smelted in considerable quantities in Southern India, in Rajputana, and at various places along the outer Himalaya in which a persistent belt of killas-like rock is known to be copper-bearing in numerous places, as in Kulu, Garhwal, Nepal, Sikkim, and Bhutan. In Chota Nagpur several attempts have been made to work lodes reputed to be rich in the metal, but in all such attempts the ore has been smelted for the metal alone and no effort has been made hitherto to utilise the accompanying sulphur as a by-product. At Baraganda in the Giridih sub-division of Hazaribagh, a low-grade ore-body of about 14 feet in thickness has been prospected by shafts to a depth of 330 feet, and an unsuccessful attempt was made some years ago to work the lode.

Singhbhum.

In the Singhbhum district (Bihar and Orissa) a copper-bearing belt marked out by old workings persists for a distance of some 80 miles, stretching from Duarparam on the Bamini River in the Kera Estate, in an easterly direction through the Kharsawan and Saraikela States, into Dhalbhum, where the strike of the belt curves round to south-east, running through the Rajdoha and Matigara properties of the Cape Copper Company, Ltd., to Bhairagora at the extreme south-eastern end.

The copper ores occur as rather indefinite lodes interbedded with the Dharwar phyllites and schists; sometimes the ore is collected into fairly well-defined bands, but very frequently it occurs in the form of grains so sparsely disseminated through a considerable thickness of schists as to be unworkable; whereas, if the same amount of copper minerals had been concentrated into a smaller thickness of schists, workable deposits of ore would have been formed. When concentrated into definite lodes, as at Matigara, the ore may be of fairly high grade, and well worth working, if it can be proved to exist in sufficient quantity to render it worth while to erect the plant necessary to handle large quantities of ore.

These copper-ores have been the subject of exploitation on European lines by various companies during the past fifty years, always until lately with disastrous results, in some cases due to the poor character of the deposit attacked, and in others to the unwise expenditure of a limited capital on expensive plant before the deposit had been proved. Such results caused business and mining men to avoid the Singhbhum copper and consequently, in the absence of private enterprise, the Geological Survey of India, during the years 1906 to 1908, carried out a series of diamond-drilling operations on the belt. This directed attention to the problem, and the Cape Copper Company, after a further prospecting campaign, took over the Rajdoha Mining Company's rights at Matigara. The property, now known as Rakha Hills Mines, is being actively developed and had it not been for the difficulty of procuring plant during the war smelting furnaces would have been in full operation before the end of the period under review.

Cape Copper Co.'s Rakha Mines.[1]

By the end of 1918 the main shaft (No. 1) had been sunk to a depth of over 1,100 feet on the Incline and the ore shoot had been opened up ready for stoping by a series of drifts connected by rises.

[1] Kindly revised and brought up to date (end of 1919) by Mr. E. D. McDermott.

Another shaft, No. 4, has been sunk to over 300 feet on a second ore-shoot 3,500 feet south-east from No. 1 and at the end of August 1918 the ore reserves amounted to 407,000 short tons of an average assay value of 3·8 per cent. copper. An electric power house, concentration plant, and blast furnace with sintering and converting plants have been erected; and by the end of 1918 work had been started on the erection of a refinery. During the war, owing to the difficulties and delays in obtaining first the necessary plant and, later, coke for the furnace, it was found impossible to start regular production and only about 30 tons of blister copper were produced from a few short campaigns.

The following table shows the production of copper ore from the mine during the period under review :—

Year.	Output.	Value of Mineral.
	Tons.	Rs.
1914	4,400	99,000
1915	8,010	180,225
1916	4,135	93,037
1917	20,108	452,430
1918	3,619	60,795

As seen at the outcrops the Singhbhum lodes seem to be very poor indeed where they have not been removed by the ancients. Typically they consist of a small thickness of vein quartz, associated with malachite, chrysocolla, and red oxides of iron containing a small quantity of copper, possibly as red oxide, with sometimes small encrustations of liebethenite. In depth, as seen in the diamond drill cores and the levels of the Matigara mine, the ores consist practically entirely of chalcopyrite. The other minerals noticed above are evidently the outcrop alteration products of the yellow sulphide. Judging from small specimens found on the dump-heaps of the old workings there must be a zone of chalcocite not very many feet below the surface, probably formed by secondary

TABLE 37.—*Production of Copper ore during 1914 to 1918.*

	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa.	4,400	*6,600*	8,010	*12,015*	4,135	*6,202*	20,108	*30,162*	3,619	*4,053*	8,054	*11,806*
Burma .	924	*693*	875	*2,366*	...	...	...	...	...	...	899(*a*)	*1,529*(*a*)
United Provinces.	·02	*1*	...	...	...	...	...	...	...	...	...	...
TOTAL .	**5,324·02**	*7,294*	**8,885**	*14,381*	**4,135**	*6,202*	**20,108**	*30,162*	**3,619**	*4,053*	**8,414**	*12,418*

(*a*) Two years.

enrichment at the expense of the portions of the deposits denuded away, and of those now appearing as gossans of oxide ores. The primary chalcopyrite ores have probably been deposited in their position as rather indefinite lodes following the bedding of the schists, after the arrival of the latter in their present position. The schists with which the copper lodes are associated are chiefly varieties of muscovite and chlorite-quartz-schists, with quartzite layers. Apatite and tourmaline are also common minerals in them.

The information obtained in the borings put down by the Geological Survey is shown in table 38. These results show that, generally speaking, the ores of Singhbhum are of low grade, and on the whole just below what is likely to be payable except when working on very large quantities of ore. A thickness of 16·80 feet, averaging 2·65 per cent. of copper found at Laukisra, should, however, lead to the further testing of this occurrence by private enterprise.

The characteristic and persistent band of chalcopyrite with quartz blebs intersected by the Matigara bore-hole at 736 feet, where it yielded 12·81 per cent. of copper, but was only 3 inches thick, and which was seen in the Matigara mine in the 228-foot level with a thickness ranging from 6 inches to 2 feet, has now been followed on the dip in the Gladstone Shaft and found to extend below the depth proved by boring.

TABLE 38.—*Results of Diamond-drill Boring on the Singhbhum Copper Lodes.*

No. of bore-hole.	Locality.	Total depth of hole.	Depth of lode or cupriferous zone.	Actual thickness of lode assayed.	Percentage of copper.
1	Kodomdiha . .	...	392′—404′ .	8 feet . .	5·10
2	Do. . .	1,093′	1,069′ . .	1 foot . .	1·82
3	Galudih (Regadih) .	430′	131′—294′ .	...	...
			293′	13 inches . .	0·61
4	Landup (Nadup) .	465′	197′—198′ .	14 inches . .	3·33
5	Matigara . .	837′	693′—697′	3 feet 2 inches .	2·00
			697′—701′ 8″	3 feet 8 inches .	1·29
			733′ 5″—736′ 1″	2 feet 1 inch .	1·01
			736′ 1″—736′ 5″	3 inches . .	12·81
			736′ 5″—739′	2 feet . .	0·42
6	Laukisra . .	392′	150′—168′ .	16 feet 10 inches .	2·65
			169′—171′	1 foot 10 inches .	2·13
			179′—184′	4 feet 8 inches .	1·37

Himalaya. With reference to copper in the Himalaya, attention may be drawn to a note on a copper deposit near Komai, Darjeeling district,[1] and to one on the copper of Garhwal and Kumaon.[2]

Sikkim. Recent work has also proved the existence of lodes of possible value in Sikkim, where the copper is associated with bismuth, antimony, and tellurium, one of the minerals discovered being the rare mineral tetradymite Bi_2Te_3. Another mineral identified by the late Mr. Blyth in the Geological Survey Laboratory is linnæite, a sulphide of cobalt, Co_3S_4.

Prospecting licenses and mining leases were secured by Messrs. Burn & Co., in the copper-bearing areas in Sikkim, and extensive prospecting operations were conducted for some years; they were suspended, however, during the war, and have not been resumed.

The following notes are from a report made in October 1908 by Mr. C. Wilkinson, showing the principal results obtained up to that date[3] :—

At Bhotang, 44 miles from Siliguri on the road to Gangtok, some old workings were examined and two parallel lodes of pyrrhotite were opened up and found to contain varying quantities of zinc blende, galena, and chalcopyrite. The lodes are disturbed, but development work yielded results which were regarded as satisfactory.

At Dikchu, about 7 miles to the north of Gangtok and within a mile of the Gangtok-Lachen road, a distance of 75 miles from Siliguri, a more clearly defined copper-lode was discovered. It was found, by opening up the outcrops for a length of 200 feet along the bed of the Sehchu, that the lode had an average width of 3 feet, bearing 6·14 per cent. of copper. By cutting the vein at a greater depth with an adit it was found that for 80 feet on an average width of 40 inches the lode contained an average content of 6·8 per cent. of copper.

In the Rhotak Colah, a tributary of the Great Ranjit river, 13 miles by pack road from Darjeeling, there are extensive old workings which have been almost obliterated by landslips. Five samples of the lode, taken at irregular intervals along a length of 500 feet, gave an average of 5·6 per cent. of copper.

[1] H. H. Hayden, *Rec. Geol. Surv., Ind.*, XXXI, p. 1 (1904).
[2] J. Coggin Brown, *Rec. Geol. Surv., Ind.*, XXXV, p. 35 (1907).
[3] Published with the kind consent, through the late Mr. A. Whyte, of Messrs. Burn & Co.

At Sirbong, about 1 mile north-east of the junction of the Rhotak and Khani Colahs, a lode of pyrrhotite containing chalcopyrite was exposed, yielding, for an average thickness of 2 feet 6 inches, 6·45 per cent. of copper, the sampling being continued for about 100 feet along the outcrop.

The Pachikhani mine, which is reputed among the natives to be one of the richest of the mines in Sikkim, has been overwhelmed by a landslip, and has not yet been sufficiently opened for further examination (see Mr. Bose's remarks on this mine in *Records, Geological Survey of India*, Vol. XXIV, page 227).

Another deposit was found near Pachikhani on the road from Rungpo to Pakyong, about 7 miles from the former locality. It was found that the chalcopyrite, concentrated within a zone of mica-schist about 4 feet wide, yielded on an average 4 per cent. of copper, and it is proposed to test the occurrence more fully by diamond drilling.

Within 200 yards of the bridge crossing the Rungpo on the road from Rungpo to Rhenok, and about a mile to the north-east of the second of the two Pachikhani mines, there was found a quartzose vein following the foliation-planes of the Daling series and containing 3·97 per cent. of copper for an average thickness of 1 foot; it is considered that this ore can be readily concentrated by handpicking.

In the neighbourhood of Pakyong in the Pachi Colah valley, two veins were found cropping out at right angles to the stream and at a distance of 200 yards from each other. The average analysis of the samples collected from one of these lodes gave the following results :—

Copper	3·30
Iron .	11·23
Lead .	10·10
Zinc .	2·50
Sulphur	11·68
Silica	40·10

The other lode, consisting mainly of galena, varied in thickness from 6 inches to 2 feet, and contained an average of 21·12 per cent. of lead with 5·9 per cent. of zinc.

In 1911 the two most important of these deposits, namely, Bhotang and Dikchu, were examined by the Geological Survey of India.[1] As the result of this examination, development work was resumed at Bhotang with favourable results. Both deposits occur

[1] L. L. Fermor, *Rec. Geol. Surv., Ind.*, XLII, p. 75 (1912).

interbedded with the associated rocks, being of the nature of interbedded replacement deposits; but whereas the Bhotang deposit is in a comparatively unmetamorphosed form of the Daling series, the Dikchu deposit occurs in the belt of highly crystalline mica-schists with associated gneisses, forming a boundary zone between the Daling series and the Sikkim gneiss. In both cases, the copper-ore is chalcopyrite, the chief associated sulphide being pyrrhotite. But, especially at Bhotang, galena and blende are also of somewhat common occurrence. The origin and mode of occurrence of these ores appear to be similar to those of the Singhbhum copper lodes. In each area the lodes are interbedded in the Archæan rocks (Dharwars in Singhbhum and Dalings in Sikkim, the garnetiferous rock of Dikchu being probably a highly metamorphosed form of the Dalings); in each area the bodies of copper ore have been formed by the metasomatic replacement of the associated rocks; and in each area the copper-bearing formations are close to large masses of granitic rocks, from which, one may conjecture, the copper-bearing solutions were derived. In Singhbhum there are numerous basic (epidioritic) dykes associated with both the granites and the Dharwar rocks (schists, quartzites, etc.), and, as an alternative to the derivation of the copper-bearing solutions from the granites, it is possible to suppose them to be closely connected with the basic dykes. The disposition of the Singhbhum copper deposits as an aureole in the Dharwars following the curvature of the Dharwar-granite boundary is, however, in favour of the former suggestion, which, as it happens, is also more suitable for explaining the derivation of the ores of Sikkim, where basic igneous intrusions are scarce.

Although the deposits of Sikkim are similar in mode of origin to those of Singhbhum, they differ from them remarkably in the diversity of their mineral contents, which frequently include chalcopyrite, pyrite, pyrrhotite, blende, and galena; in Singhbhum, on the other hand, the copper-lodes show, as a rule, only two sulphide minerals, chalcopyrite and pyrite, with traces of chalcocite at higher levels, probably representing a zone of secondary enrichment. In both Sikkim and Singhbhum, azurite, malachite, chrysocolla, and chalcanthite are found in the oxidised zones of the lodes, but in Sikkim, where the slopes are very steep and denudation under the influence of a moist climate and heavy rainfall very rapid, the oxidised zones are much less prominent than in Singhbhum

In Sikkim the sulphide minerals may crop out at the surface in the fresh condition, but this practically never happens in Singhbhum, where one might doubt the existence of copper deposits, were it not for the presence of numerous ancient outcrop workings stained with green and blue oxidised copper minerals.

Burma.

Copper is also found at Bawdwin in the Northern Shan States, and a high-grade copper-silver ore, carrying 10·9 per cent. copper and 23 ounces of silver to the ton, is said to have been found recently in several bodies in that mine; the reserves of this ore in 1919 were stated to be over 300,000 tons. Copper ore is also found in Myitkyina and Katha districts, but no regular operations are carried on in either, and no ore-bodies of any value have yet been proved.

Indian consumption of copper and brass.

That there is plenty of scope for the development of copper deposits in India to satisfy the Indian demand is seen by the magnitude of the imports of copper and brass. The average annual values of these for the period under review are shown in table 39, together with the exports of Indian copper and brass wares (manufactured from imported metal), and the re-exports of foreign copper and brass. From these it is seen that the value of the average annual consumption has been £801,723 in the case of copper and £517,057 in that of brass, as against £2,066,395 and £70,008 respectively in the previous quinquennial period.

TABLE 39.—*Average Annual Exports and Imports of Copper and Brass for the five years 1914-15 to 1918-19.*

	COPPER.		BRASS.	
	£	£	£	£
IMPORTS	...	848,816	...	558,432
EXPORTS—				
Of Indian merchandise	19,040	...	13,047	...
Of foreign merchandise	20,065	...	5,191	...
Of Government stores	7,988	...	22,537	...
TOTAL EXPORTS	...	47,093	...	41,375
Indian Consumption	...	**801,723**	...	**517,057**

Diamonds.

[E. H. PASCOE.]

Distribution in India.

Notwithstanding the reputation (stretching back even as far as Ptolemy in the European, and further in the Hindu, classics) which India has had as a diamond-producing country, the output of to-day is very small and comparatively unimportant. The places which, according to accounts, have been most productive in the past form three great groups, each in association with the old unfossiliferous rocks of probable pre-Cambrian age, now known as the Purana group, and distinguished locally as the Cuddapah and Karnul systems in South India, and as the Vindhyan system in the northern part of the Peninsula.

Southern group of occurrences.

The southern of the three groups of diamond-occurrences includes localities, with apparently authentic records, in the districts of Cuddapah, Anantapur, Bellary, Karnul, Kistna, and Godavari. Loose stones have been picked up on the surface of the ground, found in deposits of alluvium and in workings that have been undertaken in the so-called Banganapalle stage of the Karnul series of strata.

Eastern group of occurrences.

In the second group of occurrences, in the Mahanadi valley, the stones have been found in the alluvium of the Sambalpur and Chanda districts, but, though strata similar to those of the Vindhyans and Karnuls are known in this area, no diamonds have been found in these older rocks.

Central Indian occurrences.

The third group of occurrences occupies a tract some sixty miles long by ten miles wide, with the Vindhyan conglomerates near Panna as the centre. The diamond-mining industry still persists in this area, both in the old conglomerate of Vindhyan age, and in the alluvium derived therefrom. The States in which diamonds are found are Panna, Charkhari, Bijawar, Ajaigarh, Kothi, Pathar Kachhar, Baraunda, and Chobepur.

The following scale of strata will give an idea of the position of the diamondiferous beds with reference to the Upper Vindhyan rocks exposed in the Central India area —

BHANDER SERIES . . .	Upper Bhander sandstone. Sirbu shales. Lower Bhander sandstone. Bhander limestones. Ganurgarh shale.

Diamondiferous horizon.

REWA SERIES	Upper Rewa sandstone. Jhiri shales. Lower Rewa sandstone. Panna shales.

Diamondiferous horizon.

KAIMUR SERIES . . .	Upper Kaimur sandstone. Kaimur conglomerate. Bijaigarh shale. Lower Kaimur sandstone.

The following is a summary of the principal results of a study by Mr. E. Vredenburg,[1] of the diamond-fields of Central India :—

In the neighbourhood of Panna the principal diamond-bearing stratum is a thin layer of conglomerate, locally known as 'mudda' lying between the Upper Kaimur sandstone and the Panna shales. The conglomerate is seldom thicker than two feet and does not form a continuous bed. Further east, in the neighbourhood of Itwa, the diamondiferous conglomerate does not rest directly on the Kaimur sandstone, but is separated from it by a 20-25-foot bed of shales and limestone. Another diamondiferous conglomerate occurs above the Rewa sandstones and under the Bhander series. This conglomerate differs from that below the Rewa series in the abundance of pebbles of vein quartz, instead of the different varieties of jasper found so commonly in the main diamondiferous conglomerate near Panna.

The diamonds in these conglomerates, like the associated large pebbles of lighter rocks, are derived from older rocks, and the original home of the gem is still unknown, though a precise recognition of the associated pebbles will gradually indicate the direction in which the mother-rock once occurred and possibly still exists. The most characteristic pebbles in the diamondiferous conglomerates are the jasper-pebbles derived from the Bijawar formation and the vein quartz similar to that traversing the Bundelkhand granites, the latter being especially abundant in the conglomerate lying above the Rewa sandstone.

Besides the diamonds lying still embedded in the conglomerates others are found in the neighbouring detritus derived from the disintegration of the Vindhyan beds. The workings are developed accordingly—some with a view to the removal of the undisturbed

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 261—314 (1906).

conglomerate, and others with the intention of recovering the diamonds included in the more recently distributed detritus.

The undisturbed conglomerate is often covered by considerable thicknesses of younger Vindhyan rocks, and is reached by workings which are often, but not always, deep. These may be called 'direct workings.' In other places the overlying younger rocks have been removed by weather agents, and the conglomerate thus exposed at the surface is available for 'shallow workings.' In the detritus removed from the original conglomerate and deposited in river-valleys the diamonds may be reached by superficial, shallow, or comparatively deep workings, and they may be all spoken of conveniently as 'alluvial workings.'

Production.

The figures returned for diamonds relate to the production in the Central Indian States of Charkhari and Ajaigarh, with the addition of Bijawar and Baraunda. The production during the five years under review is shown in table 40, the average for Central India being 42·57 carats worth £1,216 as compared with 45·94 carats worth £853 during the previous five years.

TABLE 40.—*Production of Diamonds in Central India during the years 1914 to 1918.*

YEAR.	CENTRAL INDIA.		
	Quantity.	Value.	Daily labour.
	Carats.	£	Persons.
1914	54·65	*791*	913
1915	35·99	*603*	555
1916	20·42	*361*	614
1917	28·52	*1,700*	519
1918	73·29	*2,625*	2,376
Average .	*42·57*	*1,216*	*995*

Although no official returns are available, private but unconfirmed reports indicate that every year a certain number of valuable

diamonds are picked up after showers of rain in the neighbourhood of Wajra Karur in the Anantapur district of the Madras Presidency.

During 1910-12, Mr. A. Ghose prospected a concession at Viraypalle in the Karnul district. The bed of diamondiferous conglomerate was found to vary between 3 inches and 2 feet in thickness and to yield from $\frac{1}{5}$ to $\frac{1}{2}$ carat of diamond from each load of 16 cubic feet, most of the diamonds obtained being perfect crystals of fine quality and free from flaws. During the past five years no returns of the output in Madras have been forthcoming, and the working of the mines appears to have been suspended.

Gold.[1]

[E. H. PASCOE.]

The average annual production of gold in the world during the five years 1914 to 1918 is valued at nearly 90 millions sterling. Thus India, with an average annual production of £2,258,653 (from table 42) during that period, contributed only 2·4 per cent. of the total. During the four years 1904 to 1907 India occupied the seventh position amongst the leading gold-producing countries of the world; in 1908 it fell to the eighth, but in 1917 it seems to have regained its old position, according to figures from America (see table 41).

TABLE 41.—*Values of the Gold produced by the chief gold-producing countries during 1917.*[2]

COUNTRIES.	Value.
	£
Transvaal	38,296,386
United States	17,197,269
Australasia	7,381,006
Russia	3,796,098
Rhodesia	3,541,068
Canada	3,121,150
India	2,221,889
Mexico	1,848,049
West Africa	1,528,871
Other Countries	8,047,721
TOTAL	86,979,507

[1] A general account of the gold occurrences of India and Burma is given in Dr. Maclaren's 'Gold', pp. 238-270 (1908). Considerable use has been made of this in preparing this article.

[2] Figures taken from *The Mineral Industry.*

Provincial production.

Table 42 shows the provincial production for India, during the five years under review. In 1904 no less than 98·2 per cent. (by value) of the Indian output was returned by Mysore, and 1·7 per cent. by the Nizam's Dominions, leaving only 0·1 per cent. as the produce of districts directly under British administration. By 1908, owing to the development of reef mining in Dharwar and of dredging in Myitkyina, the proportion derived from districts directly under British administration had risen to 2·7 per cent. ; and, of the remainder, 94·4 per cent. came from Mysore and 2·9 per cent. from the Nizam's Dominions. During the period now under review Mysore has easily maintained its lead and in 1918 produced 94·1 per cent. of the total. The returns from Bombay (Dharwar) are blank, while the new field in Madras has maintained an average annual production of 20,895 oz. The output at Myitkyina from the Irrawadi gravels consistently dwindled to 105·57 oz. in 1918.

Vein gold : development of the Kolar field.

The produce of the Mysore State is solely derived from the Kolar district, and from a single vein or reef in that district—a reef averaging only some four feet in thickness, and payably auriferous for a distance of little more than four miles. As has been the case with all other known auriferous deposits in Peninsular India, the attention of Europeans was directed to this vein by the numerous old native workings along its strike. During the Wynaad gold 'boom' of 1878-82, several companies with huge capitals were floated to work portions of a concession over the Kolar field. Of the capital subscribed the greater portion was devoted to purchase money, and comparatively little was left for working capital. The features of the auriferous deposits were not at first grasped, and much money was wasted in mining in barren ground and amidst ancient workings, which were eventually found to reach to a depth of 300 feet. All the companies floated with such extravagant hopes in 1881-82 were moribund in 1885, and it was only a dying effort of the Mysore Company in that year that disclosed the great richness of the reef and incidentally the disposition of the auriferous chutes.

By 1887 the adjacent companies had resumed operations, and from that time up till 1905 the history of the field was one of uninterrupted progress and success. During the years 1906-08 there was a fall in the output owing to zones of lower grade ore having been reached; the grade subsequently improved locally at greater

TABLE 42.—*Quantity and Value of the Gold produced in India during the years 1914 to 1918.*

PROVINCE.	1914.		1915.		1916.		1917.		1918.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Ounces.	£	Ounces.	£	Ounces.	£	Ounces.	£	Ounces.	£
Bihar and Orissa—Singhbhum	...	...	450	*1,800*	864	*3,977*	2,462	*10,133*	2,085	*9,905*
Burma—Myitkyina	3,635·60	*13,905*	3,106·83	*11,913*	1,901·05	*7,289*	1,005·55	*3,895*	105·57	*404*
Other districts (Upper Chindwin, Katha, etc.).	68·74	*390*	75·75	*427*	81·58	*421*	73·37	*353*	65·63	*335*
Hyderabad	21,200	*80,479*	17,869·7	*68,338*	18,657·2	*71,577*	13,466·7	*52,013*	11,502·8	*44,936*
Madras	19,873	*82,959*	23,870	*101,324*	22,371	*94,789*	20,529	*87,066*	17,831	*67,219*
Mysore	562,355	*2,159,604*	571,199	*2,185,409*	554,301	*2,124,129*	536,559	*2,067,541*	504,412	*1,936,785*
Punjab	249·98	*994*	149·59	*604*	186·23	*810*	190·08	*857*	109·95	*541*
United Provinces	5·75	*24*	7·37	*31*	7·63	*31*	7·31	*31*	6·37	*27*
TOTAL	**607,388·07**	*2,338,355*	**616,728·24**	*2,369,846*	**598,369·69**	*2,303,023*	**574,293·01**	*2,221,889*	**536,118·32**	*2,060,152*

depth and it was hoped that this improvement would extend to all the deep mines. It is contended, however, by some mining engineers of considerable experience that as a general rule the grade of an ore does not improve in depth below certain limits, and T. A. Rickard [1] quotes figures to show that the Kolar ores have become poorer at great depths; the figures, which are given below, are said to represent the yield in pennyweights of fine gold per short ton of the four chief mines in the years 1899 and 1913 respectively :—

—	1899.	1913.
Mysore	27·68	14·29
Champion Reef	26·41	10·92
Nundydroog	19·60	15·95
Ooregum	14·04	13·92

The deepest mines are Champion Reef and Ooregum, which have each reached a depth of considerably over 4,000 feet measured vertically.

Neither mining nor milling offers any serious obstacles on this field. With the former the necessity for heavy timbering and filling to keep the roadways open is perhaps the most serious. But of late years considerable trouble and uneasiness has been caused by air blasts and quakes, especially in the Champion Reef and Ooregum mines.[2] The ore is not refractory, and yields its gold to a simple combination of amalgamation and cyaniding.

During the five years under review the annual tonnage crushed gradually decreased from 806,818 tons in 1914 to 713,983 tons in 1918. (These figures, returned by the Chief Inspector of Mines for Mysore, are in short tons.)

In 1905 the gold yield reached a maximum of £2,373,457, the largest ever recorded in the history of the field. Since then there has been some fluctuation in the output, although only within comparatively narrow limits; in 1918 the value of the output sank to £1,935,406. For the five years under review the value of gold extracted was £10,468,644, which is less by nearly £170,000 than the

[1] 'Persistence of Ore in Depth,' *Inst. Min. Metallurgy, Bull.* No. 122 (1914).
[2] W. F. Smeeth, 'Air Blasts and Quakes on the Kolar Gold Field,' *Bull.* No. 2, *Mysore Geol. Dept.* (1904).

value for the preceding five years. In 1905 the dividends paid reached their maximum value, £1,066,615, for the whole period of the industry; there was then a marked annual decline to £582,488 in 1908, after which they rose steadily to about £750,000 in 1912. From that date another decline commenced, the dividends falling from £726,737 in 1914 to only £372,451 in 1918. The total dividends paid during the five years under review were £2,992,150 as compared with £3,509,963 paid during the previous five years.

During the period under review dividends have been paid only by four companies, situated on the line of the Champion Reef—the Mysore, Champion Reef, Ooregum, and Nundydroog—Balaghat having ceased to pay dividends since 1907. A considerable amount of exploratory and mining work has been done by other companies on the Kolar field and elsewhere in Mysore, but hitherto without profitable result, although in several cases ore has been milled and gold won. The companies that have produced gold during the quinquennium, but have not paid dividends, are Balaghat (1914-1917), Mysore Southern Extension (1915-1917), Mysore and General Exploration (1916-1917). The following companies worked but produced no gold: The New Kempinkote Gold Field, Ltd., and the gold fields of Mysore and General Exploration, Ltd.

An important improvement scheme, making for the reduction of working expenses, and consequently for the prolongation of the life of the Kolar field, was the introduction of electric power from the Cauvery falls. This work was completed about the middle of 1902, and was designed for the conveyance of 4,000 H.P. over a double line 92 miles long. Since then, the generating plant has been increased from time to time and in 1917 supplied 97 motors aggregating 12,126 H.P. This supply is continuous, except in years of drought, when there may be short stoppages during the hot weather owing to a scarcity of water in the river Cauvery.

In order to supply power for electric lighting and the driving of motors used intermittently, a company, called the Kolar Mines Power Station, Ltd., was formed in 1903, the electricity to be generated by steam power. The company began to supply power at the end of 1904, and in 1917 supplied altogether, for intermittent power as well as for power for hoisting and lifting, 3,545,556 Board of Trade units.

The scheme of water-supply from the Bethamangala Tank, some 6 miles from the field, undertaken by the Mysore Government,

ensures the mines a supply of filtered water sufficient for all purposes.

Table 43 shows the various statistics of production for the Kolar field both for the period under review and for the previous quinquennium.

TABLE 43.—*Statistics of Production in the Kolar Gold-field.*

—	Tonnage crushed.	Value of gold extracted.	Dividends paid.	Royalty paid.
		£	£	£
1909	739,358	2,092,177	636,182	103,278
1910	783,088	2,106,133	658,584	117,803
1911	795,013	2,129,873	726,248	123,923
1912	808,507	2,158,362	749,398	126,653
1913	809,307	2,150,194	739,551	126,220
TOTAL for 1909-1913 . .	**3,935,273**	**10,636,739**	**3,509,963**	**597,877**
1914	806,818	2,162,141	726,737	130,119
1915	798,000	2,182,133	702,115	129,595
1916	768,508	2,122,958	613,032	117,090
1917	736,069	2,066,006	577,815	121,227
1918	713,983	1,935,406	372,451	109,413
TOTALS for 1914-1918 .	**3,823,378**	**10,468,644**	**2,992,150**	**607,444**

Total value of gold produced from 1882 to 1918 inclusive	50,766,319
" " dividends paid " " "	18,920,582
Royalty paid to Mysore Government from 1882 to 1918 inclusive	2,670,250

The work of the field is carried on by Europeans, Anglo-Indians, and Indians, in the following proportions, calculated from the

number employed during the year 1917, the latest for which figures are available :—

Europeans (including Italian miners)	1·7
Anglo-Indians	1·6
Indians : men	86·0
Indians : women (employed only on the surface) . .	7·7
Indians : children (under 14 years : employed only on the surface)	3·0

The following table indicates the risks attendant on mining in the Mysore State :—

TABLE 44.—*Fatal Accidents in Mysore mines for the years 1914 to 1918.*

YEAR.	Number of persons employed.	*Death-rate per 1,000 employed.*	Death-rate per £100,000 worth of gold obtained.
1914	26,290	*2·28*	2·76
1915	27,008	*2·59*	3·20
1916	25,270	*3·52*	4·18
1917	24,531	*2·81*	3·33
1918	24,517	*2·90*	3·66
Average .	*25,523*	*2·82*	*3·43*

Hyderabad (Nizam's Dominions).

The only gold-field in India besides Kolar from which there has been a continuous production of vein gold during the quinquennium is the Hutti field, situated on the Maski band of Dharwar schists in the Lingsagar district of the Nizam's Dominions (Hyderabad). The only company operating on this field is the Hutti (Nizam's) Gold Mines, Ltd. It is an offshoot of the Hyderabad (Deccan) Company and was floated in 1901. Crushing with 10 head of stamps was commenced in 1903, with a production of 3,809 ozs. of gold in that year. Since then the number of stamps has been increased to 30. One of the shafts is over 3,000 feet in depth. Dividends have been paid regularly since 1904, up to and including the year 1916, but none in 1917 and 1918. Table 45 gives the production statistics of this mine ; it will be seen that the average amount of gold extracted during the period under review has been 12·2 dwts., worth £2·337, per ton of quartz crushed.

TABLE 45.—*Statistics of Production at the Hutti Mines.*

YEAR.	Tonnage crushed.	*Bar gold produced.*	Value of gold extracted.
	Tons.	*Ozs.*	£
1914	33,425	*21,200*	80,479
1915	29,550	*17,869·7*	68,338
1916	26,360	*18,657·2*	71,577
1917	23,330	*13,466·7*	52,013
1918	23,100	*11,502·8*	44,936
TOTAL .	**135,765**	**82,696·4**	**317,343**

In 1905 another company, known as the Topuldodi (Nizam's) Gold Mines, Ltd., with a capital of £90,000 was formed to take over from the Hutti Company an option held on the Topuldodi block in the Raichur district of the Nizam's Dominions. During 1908, 2,132 ozs. of gold, worth £8,319, were produced. But as the ore developed in the mine proved to be of very low grade, the mine was closed down, and its assets transferred to the Hutti Company.

The Dharwar Gold-fields.

A third Indian field on which work was actively prosecuted during the earlier part of the former quinquennium is the Dharwar field, situated on the Gadag band of Dharwar schists, partly in the Dharwar district and partly in the Sangli State, both of which lie in the Bombay Presidency. In spite of the expenditure of much capital in very thorough development operations, the reefs were found too poor to work and the mines were abandoned in 1911.

Anantapur.

In 1902 Mr. E. W. Wetherell, of the Mysore Geological Department, discovered a previously unknown belt of Dharwar schists stretching in a north and south direction for some 32 miles through the Anantapur district of Madras, but just touching the north-east corner of the Pavagada taluk of the Tumkur district of Mysore. Several large quartz reefs occur in this belt, and near the village of Ramgiri old gold workings were found. The gold occurs in quartz veins principally in chloritic

and argillaceous schists. A company, called the Anantapur Gold Field, Ltd., was formed in 1905. In 1908 it transferred a portion of its holdings (the Buruju block) to a new company, the North Anantapur Gold Mines, Ltd., and other portions (South Jibutil block and, subsequently, North Jibutil block) under option to the Nundydroog Company of Mysore. The option was exercised and the Jibutil Gold Mines of Anantapur, Ltd., was formed to take over the properties from the Anantapur Gold Field, Ltd., on payment of £5,000 in cash and 160,000 fully paid shares, of which 20,000 went to the Nundydroog Company. The North Anantapur Gold Mines, Ltd., have carried on vigorous development work, having sunk nine shafts, one main shaft, one secondary and seven for prospecting and ventilation purposes. The capacity of the mill is 35 stamps of which 20 are in good condition and capable of crushing 1,800 tons a month. The mines, which are situated in the Dharmavaram taluq of Anantapur district, produced 2,532 ounces in 1910. Since then the output has risen steadily to nearly 24,000 ounces in 1915, since when there has been a steady decline.

The Nilgiris.

The Nilgiris, after many vicissitudes, have ceased to be a mining area; but some native workers are reported to be making a living by roughly treating the waste heaps, from which they extract a small quantity of gold.

Gold in sulphide lodes.

Besides occurring in the free state in quartz veins, as in all the areas noticed above, gold is sometimes found in sulphide lodes enclosed in the sulphide minerals. Thus gold occurs in Sikkim among the mixed sulphide lodes (chalcopyrite, pyrite, pyrrhotite, blende, etc.), and in the copper-bearing lodes of Sleemanabad in the Jubbulpore district of the Central Provinces. Assays in the latter case have occasionally shown amounts as high as 15 dwts. per ton.

Alluvial gold.

Alluvial gold-washing is carried on in Assam, Bihar and Orissa, and many other places in British India, but from the fact that the washers invariably combine this pursuit with other occupations, and because the individual return is exceedingly small and is locally absorbed for jewellery, complete returns are not available. These, so far as they go, give little hope of the discovery of rich alluvial deposits in Peninsular India, or indeed in any part of India affected by the monsoon rains and dependent on them alone for the supply of the rivers. For concentration of gold a comparatively equable current is essential—a condition

rarely obtainable in the gravel river beds of India, where alone gold would be found, for these are almost dry in the cold weather and roaring torrents in the Rains. The greater possibilities of dredging on the Irrawaddi appear to arise from the fact that the waters of that river are derived from ranges where, even in the cold weather, there is a heavy rainfall.

Assam.

In Upper Assam, tributaries such as the Subansiri, that flow from the north into the Brahmaputra, carry small quantities of gold.[1] One small bar near the mouth of the Subansiri gorge was found to contain more than a dwt. per cubic yard; but the quantity of gravel available was very small. It is probable that some of the gold of this region is derived immediately from the Tipam (Siwalik) sandstones, and that the source of the gold in the Lohit branch of the Brahmaputra is to be sought in the metamorphic rocks of the Miju ranges.

Chota Nagpur.

In the Chota Nagpur division of Bihar and Orissa, alluvial gold is found widely distributed, but the gold washing is of most importance in the Singhbhum and Manbhum districts, and is chiefly confined to the valley of the Subarnarekha ('golden-streaked') river and its tributaries. The average earnings amount to only As. 1½ to 2 a day.

The result of the work of Dr. Maclaren[2] and of other members of the Geological Survey was to show that nowhere in Chota Nagpur had gold deposits—either alluvial or vein—been found worth working on European lines. Recently, however, interest in that area revived and The Dalbhoom Gold and Minerals Prospecting Co., Ltd., was promoted in the previous quinquennium to work gold mines in Dhalbhum State. A modest output of 450 ounces was first made in 1915, but rose in 1917 to 2,462 ounces worth £10,133.

Burma: native gold-washing.

The native gold-washing industry is carried on from year to year in several districts in Burma, usually by only a few people in each district; the number so engaged varies from year to year partly in accordance with the character of the seasons. No accurate figures of production are available. In 1914 gold was washed in the districts of Katha, Myitkyina, Shwebo, and Upper Chindwin. The returns for 1918 show a production of only 65·63 ounces, derived from Katha and Upper Chindwin.

[1] *Rec. Geol Surv. Ind.*, XXXI, pp. 179-232 (1904).
[2] *Ibid*, pp. 59-91.

Burma gold-dredging; the Irrawadi.

The gold-dredging on the upper reaches of the Irrawadi was largely due to the enterprise of Mr. W. R. Moore who (in association with Captain J. Terndrup) was granted in 1901 a five-years' license for dredging within the bed of the river for a stretch of some 120 miles from the confluence above Myitkyina to the mouth of the Taiping above Bhamo. In 1904 the license was extended for a period of thirty years and restricted to about 88 miles of the river from Sinbo to the confluence, while sanction was given at the same time to transfer the concession to the Burma Gold Dredging Company, which was registered at Rangoon in 1903. In 1907 permission was given to alter the limits of the concession by exchanging 15 miles of the lower end for 10 miles along the 'N Maikha and 5 miles along the Mali-kha. Application was subsequently made for a further exchange of the Irrawadi part of the concession for 15 miles along the eastern river, 'N Maikha. This company was liquidated in 1911, and a new company formed, called the Burma Gold Dredging Company, 1911, Ltd.

For the greater part of the period 1909-1913 five dredges were at work, but the results did not come up to expectations. Expenses were cut down considerably by the substitution of Kachin for Australian skilled labour, but the output was still considerably below that of 1909, this was attributed to the poor quality of the wash remaining to be worked in the bed of the river. The annual outturn for the period 1914-18 is shown in table 46.

TABLE 46.—*Alluvial Gold won by the Burma Gold Dredging Company, 1911, Ltd., during 1914-18.*

YEAR.	Quantity.	*Value.*
	Ounces.	£
1914	3,635·60	*13,995*
1915	3,106·83	*11,913*
1916	1,901·05	*7,289*
1917	1,005·55	*3,895*
1918	105·57	*404*
Average	*1,950·92*	*7,481*

The gold-bearing alluvium is coarse gravel with the gold disseminated fairly uniformly. The average value of the gravel seems to be about 3 grains (6 annas) per cubic yard. Small quantities of platinum and platinoid metals are recovered with the gold. The average annual production of gold has declined from 6,226 oz. in the last quinquennium to 1,951 oz. in the period under review.

The Chindwin.

The alluvial stretches of the Chindwin river have been found to contain gold at many points, but systematic prospecting has in most cases shown them to be valueless as dredging propositions, although they are a source of income to the native gold washers.[1] A concession for 180 miles of the Lower Chindwin river, stretching from Minsin to Homalin, was granted about 1903 to the Burma Mines Development and Agency, Ltd., and in 1905 transferred to the Mandalay Gold Dredging Company, Ltd. A dredger was obtained, but became stranded while being towed up the Chindwin river, and no further work was attempted.

The Uyu, a tributary of the Upper Chindwin, has also been prospected for alluvial gold, but with little success so far.

The Namma.

In 1905 the Namma Gold Dredging Company, Ltd., with a capital of £70,000 (£55,000 issued, of which £30,000 went to vendors) was floated in London to work two stretches of the Namma river, a tributary of the Salwin, in the Shan States. A careful preliminary investigation had indicated the existence of approximately 40,000,000 cubic yards of gravel averaging 5·43 grains of fine gold per cubic yard. A steam dredger was purchased and floated in a paddock on the Upper Namma, and it was then found that the deposit was unfitted for this mode of exploitation. It consists of gravel and boulders embedded in a stiff clay, hardened by calcareous tufa derived from the limestone forming the sides of the valley, and is therefore not sufficiently loose to enable the buckets of the dredger to excavate it. The venture, therefore, ended in failure.

The alluvial gold deposits of Loi Twang in the Shan States, worked by native washers, have been examined in detail by Mr. T. D. LaTouche and found to be of no commercial value.[2] Alluvial deposits examined by Mr. J. Coggin Brown, in Mong Long, Hsipaw State, were also found to be too poor generally to be worth exploita-

[1] H. S. Bion, *Rec. Geol. Surv. Ind.*, XLIII, p. 341 (1913).
[2] *Rec. Geol. Surv. Ind.*, XXXV, pp. 102—113 (1907).

tion, although small patches were found to contain occasionally over 9 grains of gold to the cubic yard.[1]

Other Burmese rivers to which attention has been directed by European prospectors, without any tangible results so far, are the More Chaung, Taiping, and Shweli, tributaries of the Irrawadi; the Upper Chindwin; the Salwin; and the streams of Tavoy, where gold has been found associated with tinstone.

The Central Provinces.

Alluvial gold occurs in the sands and gravels of many of the rivers and streams of the Central Provinces, particularly in those that drain down from or run over areas where the ancient crystalline and metamorphic rocks crop out. According to an "Industrial Monograph on Gold and Silverware of the Central Provinces," by H. Nunn, I.C.S., published at Allahabad in 1904, which contains also the best account yet published of the native gold-washing industry of that province, gold-washing has been carried on at various times in the followng districts:—Balaghat, Bhandara, Bilaspur, Chanda, Jubbulpore, Mandla, Nagpur, Raipur, Sambalpur, and Seoni. From the report quoted it appears that in addition to the washers of auriferous sands there are people engaged in a cognate industry, consisting of the extraction of the gold and silver particles, called in England 'lemel,' from the dust of a *sunar's* shop and furnace by a two-fold process, first of actual winnowing, and then of washing in a river. The resultant gold is treated by refining processes. The persons practising this 'lemel' washing, which is recorded for the Balaghat, Bilaspur, and Hoshangabad districts, are Mahomedans, and it is desirable to distinguish their occupation from that of the gold-washers proper, although there is doubtless at times a certain overlapping of the two occupations. The gold-washers are variously known in different parts of the province as *jharas*, *jharias*, *sonjharas*, *sonjhirias*, and *sonzaras*. The report cited gives a full account of the methods of washing and treating the gold as practised in the Tirorā tahsil of the Bhandara district. The whole gold industry of the Central Provinces, however, is small and no reliable figures for output are available. It is not likely that more than 200 ounces are won annually.

Kashmir.

Washing for alluvial gold has been practised along the valley of the Indus in the Baltistan and Ladakh divisions of Jammu and Kashmir State. In

[1] *Rec. Geol. Surv. Ind.*, XLII, p. 37 (1912).

Kargil and Skardo, Baltistan, the washing of ancient gravel deposits has been carried out on quite an extensive scale, actual mining operations having been undertaken to excavate the gold-bearing bands in the old river terraces in the Dras valley. The production of gold from Kashmir in 1910 was returned as 236 oz., since when no returns have been received. A small quantity of alluvial gold is said to have been obtained formerly by Tibetans from sub-recent gravels on the Para river on the border between Rupshu and the Tibetan Province of To-tzo.[1]

Punjab.

Gold-washing is carried on also in some of the Punjab rivers, especially the Indus, and the production for the quinquennium totals 886 oz., giving an average annual figure of 177 oz.

United Provinces.

In the United Provinces the industry was reported in 1904 as employing about 100 workers in the Nagina tahsil of Bijnor district, and smaller numbers in Garhwal and Naini Tal. The total reported production during the quinquennium was 34½ oz.

Graphite.

[H. H. HAYDEN.]

Mode of occurrence.

Graphite occurs in small quantities in various parts of India— in the so-called khondalite series of rocks in the Vizagapatam hill-tracts and adjoining Chhattisgarh Feudatory States, in a corresponding series of rocks in Coorg, in the Godavari district of the Madras Presidency, in the Ruby Mines district in Upper Burma, and in Travancore. It has also been discovered in Sikkim, where a graphite vein, averaging about 13 inches in thickness, was found during the prospecting operations conducted by Messrs. Burn and Co. at about half a mile to the north of the road from Tsuntang and Lachen. The quality of the mineral is said to be good, large bulk samples having given a return of 93 per cent. of graphite. Other veins of graphite are known to occur in the area, but have not been examined in detail.[2] It is also found in Ajmer-Marwara (Rajputana), and that

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p 102 (1904).
[2] According to a report by C. Wilkinson, communicated by the late Mr. A. Whyte of Raniganj.

district and Kalahandi have been responsible for a slight revival of the industry, which had died out in the year 1912.

The graphite deposits of Travancore occur under conditions similar to those of Ceylon, which is but a continuation of the charnockite series and associated rocks of South India. The Ceylon graphite has been made the subject of an elaborate study by E. Weinschenk, who regards it as of igneous origin,[1] a conclusion in agreement with its occurrence in South India.[2] Small quantities of graphite have been extracted in Godavari and Vizagapatam,

Production.

but formerly practically the whole of the Indian production came from Travancore, where the average output used to be about 13,000 tons annually. Owing to difficulty of working at increased depths, however, the mines were no longer found to pay and were shut down in 1912. In 1915 the impossibility of obtaining graphite from abroad threw India on to her own resources; an indigenous supply again became necessary, various known deposits were opened up and there was an output of 1,318 tons in 1916. Most of this came from Rajputana, and, like the Kalahandi material, is derived from raw material of comparatively low grade.

TABLE 47.—*Production of Graphite during the years 1915 to 1918.*

—	1915.		1916.		1917.		1918.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.*	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa—								
Kalahandi	16·5	*11*	252	*168*	60·4	*242*	80	*320*
Rajputana—								
Ajmer-Marwara	54·5	*147*	1,066·4	*1,333*	42·3	*305*	1	*41*
TOTAL	71	*158*	1,318·4	*1,501*	102·7	*547*	81	*361*

[1] Die Graphitlagerstätten der Insel Ceylon. *Abhand., d. k. Bayer., Akad.*, 1901, xxi, pp. 279—335.

[2] Holland. The Charnockite Series, *Mem. Geol. Surv. Ind.*, XXVIII, p. 126 (1900); and the Sivamalai Series, *Mem. Geol. Surv. Ind.*, XXX, p. 174 (1901).

Iron.

[H. H. HAYDEN.]

Production.

Bihar and Orissa is the only province in India in which iron-ore is mined for the production of iron and steel by European methods. In Burma, a considerable amount of ore is won, but this is entirely for use as a flux in the Burma Corporation's lead furnaces at Namtu. Table 49 shows the annual production in Bihar and Orissa during the last ten years. From this it will be seen that the production suddenly increased in 1911 by nearly 300,000 tons, the output rising from 42,653 tons in the preceding year to 342,342 tons in 1911. This was due to the operations of the Tata Iron and Steel Co., whose works at Sakchi were completed towards the end of that year; large quantities of iron-ore were therefore raised from their Gurumaishini deposits in Mayurbhanj State with a view to bringing the blast furnaces into operation. From 1911 onwards the output of ore has been of the same order of magnitude. It will be noticed that the value returned for the ore has fallen from an average of 1·85 shillings per ton to 1·62 shillings per ton during the period under review. This figure is of course merely nominal, there being no market for ore in the country and no export trade. For the total production for each year see table 48.

General character of the iron-smelting industry.

The pages of the *Records* and *Memoirs* of the Geological Survey for the past fifty years contain ample evidence of the attention that has been paid to the iron-ores of India, but it was only within the last few years that any successful attempt has been made to establish an iron and steel industry on modern lines. On the other hand, iron-smelting was at one time a widespread industry in India, and there is hardly a district away from the great alluvial tracts of the Indus, Ganges, and Brahmaputra, in which slag-heaps are not found, for the primitive iron-smelter finds no difficulty in obtaining sufficient supplies of ore from deposits that no European iron-master would regard as worth his serious consideration. Sometimes he will break up small friable bits of quartz-iron-ore schist, concentrating the ore by winnowing the crushed materials in the wind or by washing in a stream. Sometimes he is content with ferruginous laterites, or even with the small granules formed by the concentration of the rusty cement in ancient sandstones. In

ancient times the people of India seem to have acquired a fame for metallurgical skill, and the reputation of the famous *wootz* steel, which was certainly made in India long before the Christian era, has probably contributed to the general impression that the country is rich in iron-ore of a high-class type. It is true that throughout the Peninsula, which is so largely occupied by ancient crystalline rocks, quartz-hematite and quartz-magnetite schists are very common in the Dharwarian system, the system of rocks that lithologically, as well as stratigraphically, corresponds approximately to the Lower Huronian of America. But most of these occurrences consist of quartz and iron-ore so intimately blended that only a highly siliceous ore of a low grade can be obtained without artificial concentration. These occurrences of quartz-iron-ore schist are so common in India that newly recorded instances are generally passed over as matters of very little immediate economic interest. During the past few years, however, ore-bodies of great size and richness have been recognised in a belt running through the southern districts of Bihar and Orissa and constituting what is probably one of the great groups of iron ore deposits of the world.

Attempts to introduce European processes.

Earlier attempts to introduce European processes for the manufacture of pig-iron and steel, in India, had been such conspicuous failures that there was naturally some hesitation in reposing confidence in the project launched by Messrs. Tata, Sons and Co. Perhaps the earliest attempt to introduce European processes was due to the enthusiasm of Mr. Josiah Marshall Heath of the Madras Civil Service, who, having resigned the service of the East India Company, obtained the exclusive privilege of manufacturing iron on a large scale in the Madras Presidency. In 1830, trial works were erected at Porto Novo in the South Arcot district, and were maintained by subsequent financial assistance from the East India Company. The business was taken over in 1833 by the Porto Novo Steel and Iron Company, and additional works were started at Beypur on the Malabar Coast. Various concessions were granted to Mr. Heath and the succeeding Iron Company, but in spite of these, the undertaking proved to be a failure. In 1853, a new association, known as the East India Iron Company, was started with a capital of £400,000. This company obtained various concessions from Government, and erected two blast furnaces, one in the South Arcot district, and another on

TABLE 48.—*Quantity and Value of Iron-ore raised during the years 1914 to 1918.*

PROVINCE.	1914.		1915.		1916.		1917.		1918.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bengal (Burdwan)	1,204	*171*	2,243	*370*	...	...	...	...	...	...
Bihar and Orissa	402,237·3	*32,341*	367,747·8	*27,256*	391,176	*32,190*	380,813·5	*31,321*	459,667·6	*38,627*
Burma . .	19,482	*568*	15,526	*388*	16,081	*402*	28,763	*1,264*	26,680	*932*
Central Provinces	18,402	*3,198*	4,747	*986*	4,464·3	*1,493*	3,669	*978*	6,097	*1,546*
Other Provinces and States.	249	*38*	75	*10*	87·5	*14*	111	*13*	224·5	(*a*)
TOTAL, STATUTE TONS AND £.	441,574·3	*36,316*	390,338·8	*29,010*	411,808·8	*34,099*	413,356·5	*33,576*	492,669·1	*41,105*

(*a*) Not available.

TABLE 49.—*Iron-ore raised in Bengal and Bihar and Orissa during the years 1909 to 1918.*

Year.	Burdwan.	Singh-bhum.	Man-bhum.	Sambal-pur.	Mayur-bhanj.	Puri.	TOTALS FOR BENGAL AND BIHAR AND ORISSA.		
							Quantity.	*Value.*	Value per ton.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	£	s.
1909 .	46,623	15,215	10,132	737	..	..	72,707	*13,698*	3·77
1910 .	24,387	17,646	..	620	..	..	42,653	*6,618*	3·10
1911 .	5,456	36,276	..	610	300,000	..	342,342	*28,179*	1·64
1912 .	9,882	83,425	..	608	471,232	..	565,147	*43,087*	1·52
1913 .	8,926	98,196	..	666	247,025	..	354,813	*35,582*	2·00
1914 .	1,204	151,662·3	..	617	249,910	48	403,441·3	*32,512*	1·61
1915 .	2,243	127,040	..	386	240,268·8	53	369,990·8	*27,626*	1·49
1916 .	..	150,258	..	343	240,520	55	391,176	*32,190*	1·64
1917 .	..	184,815	..	377·5	195,621	..	380,813·5	*31,321*	1·64
1918 .	..	120,363	..	401·6	338,903	..	459,667·6	*38,627*	1·68
Average	*14,051·6 (7 years).*	*98,489·6*	..	*536·6*	*285,435*	*52 (3 years).*	338,275·1	*28,944*	*1·71*

NOTE.—Ore raised in Burdwan, Singhbhum and Manbhum is for the Barakar Iron-works. That raised in Sambalpur is smelted in native furnaces. That raised in Mayurbhanj is for the Tata Iron and Steel Co.'s works.

the Cauvery river, in the Coimbatore district. These furnaces were stopped in 1858, whilst operations at Porto Novo ceased in 1866, and at Beypur in 1867. Other attempts to introduce European processes have been made in the Birbhum district of Bengal and at Kaladhungi in Kumaon. But the first scheme which proved to be a financial success is that now in operation near Barakar in Bengal. Even the Barakar Iron Works passed through various vicissitudes of fortune, and showed no signs of financial success until they were taken over by the present Managing Agents, Messrs. Martin & Co.

Bengal Iron and Steel Company, Barakar.[1]

The Barakar Iron Works were taken over by the present Company in 1889 and completely remodelled. It is now (1919) a four furnace plant, with a fifth in course of erection. Three furnaces are in operation with a daily output of 300 tons of pig. In 1917

[1] Kindly revised by Messrs. Martin and Co., Managing Agents of the Bengal Iron and Steel Company.

the Allies were faced with a very serious shortage of ferro-manganese and at the direct request of the Ministry of Munitions the Company commenced the manufacture of ferro-manganese from indigenous ores. During the five years under review the production of pig has been as follows :—

	Tons.
1914	72,444
1915	87,285
1916	92,250
1917	80,252
1918	49,348

The following are the average analyses of the pig iron produced :—

—	Grades 1, 2 and 3.	Foundry pig, 3 and 4.
	Per cent.	Per cent.
Graphitic carbon	3·13	2·98
Combined „	0·23	0·32
Silicon	2·99	2·26
Phosphorus	1·20	1·21
Manganese	1·40	1·13
Sulphur	0·022	0·03

The production of ferro-manganese was as follows :—

	Tons.
1917	2,257
1918	12,114

The ferro-manganese produced had an average manganese content of 75 per cent.

Castings.

The iron foundries cover an area of approximately 120,000 square feet and include pipe foundries, sleeper foundries and a foundry for general and special castings, this latter being especially equipped for heavy work. There is also a modern machine shop for machining castings. During the five years 1914—1918 the production of iron castings was as follows :—

	Tons.
1914	18,048
1915	25,634
1916	30,605
1917	20,678
1918	21,776

The blowing engines include three Parson's turbo blowers two of a capacity of 25,000 cubic feet per minute up to 10 lbs. pressure, one of a capacity of 18,000 cubic feet per minute up to 7 lbs. pressure, and two Barclay engines. A fourth blower has just been installed of 50,000 cubic feet per minute capacity at 7 lbs. pressure.

Coke.

The coke used is made at the Company's works in two batteries of 34 ovens each of Messrs. Simon Carvès regenerative by-product recovery ovens, one being of the waste gas type the other being of the waste heat. Two other batteries each of 34 ovens but of larger capacity are under construction. The present output of coke is 8,000 tons monthly and this will be increased to 18,000 tons on the completion of the other two batteries. Tar and ammonia are recovered from the waste gases; the sulphuric acid used in the direct process for the recovery of the ammonia from the coke oven gases is made in an intensive plant also at the Company's works.

Coal.

The coal supply is obtained from the Company's collieries at Ramnagar adjacent to the ironworks and connected thereto by a light railway and at Nunodih and Jitpur in the Jharia field.

Flux.

The limestone used as a flux is obtained principally from the Vindhyan beds at Sutna in the Rewa State and gives the following average analysis:—

	Per cent.
Calcium carbonate	90·62
Silica	6·25
Ferric oxide and alumina	1·10
Magnesium carbonate	1·86

Subsidiary supplies are also obtained from the Kalyanpur deposits near Dehri-on-Sone, East Indian Railway.

Iron ore.

The site of the Barakar ironworks was originally chosen on account of the proximity of both coal and ore deposits. The outcrop of Ironstone Shales between the coal-bearing Barakar and Raniganj stages stretches east and west from the works and for many years the clay-ironstone nodules from this formation constituted the only supply of ore used in the blast furnaces. This source of supply however has been discontinued for some years in favour of the ore from the Company's deposits in the Kolhan estate, Singhbhum and at

Ghatsila in Dhalbhum. The main deposits are known as Pansira Hill and Buda Boru Hill situated about 12 miles and 8 miles respectively south-east of Manharpur station Bengal-Nagpur Railway. The total quantity of ore in sight in these two deposits is estimated at not less than 10 million tons. The ore is a high-grade hematite with an average analysis of—

	Per cent.
Iron	64·0
Silica	2·10
Lime	·15
Alumina	1·25
Magnesia	·18
Manganese oxide	·05
Sulphur	·002
Phosphorus	·05

A 2′ 6″ railway line has been constructed by the Bengal Iron and Steel Company, Limited, from Manharpur to Pansira with a branch through the Ankua valley to Buda. An aerial ropeway with a capacity of 50 tons hourly transports the ore from the top of Pansira Hill to the light railway at the foot. The use of this ore makes the quality of the Company's pig iron equal to that of the best known imported brands. The following table shows the quantity of ore used during the period under review :—

	Statute tons.
1914	118,045
1915	140,135
1916	143,922
1917	137,026
1918	84,057

Labour.

The average number of persons employed daily at the Barakar Ironworks, exclusive of labour employed by contractors, was as follows :—

1914	5,735
1915	6,333
1916	7,150
1917	6,738
1918	7,201

Contractors' labour varies in numbers but is estimated at from two to four thousand.

The Tata Iron and Steel Company, Limited.[1]

The Tata Iron and Steel Co.'s works are situated at Jamshedpur (Sakchi) in the Singhbhum district to the north of Tatanagar (Kalimati) railway station, 153 miles from Calcutta, near the junction of the Khorkai and Subarnarekha rivers, from which is drawn the water required for the works and the town.

The plant consists of coke ovens, blast furnaces, steel plant, rolling mills, power house, foundries, machine forge, pattern-, pipe- and structural shops, stores and the necessary yards and transportation equipment.

The original coke oven plant consisted of 180 Coppée non-recovery ovens and 30 bee-hive ovens, producing altogether about 15,000 tons of coke monthly. To this have been added 50 by-product recovery ovens and 300 bee-hive ovens, bringing the monthly production of coke to approximately 32,000 tons.

There were originally two blast furnaces, producing about 15,000 tons of pig iron per month. One more blast furnace has since been added and the maximum monthly production at present is approximately 25,000 tons.

The original steel plant consisted of one 300 tons acid-lined gas-fired mixer, four 45-ton basic open-hearth furnaces and three gas-fired soaking-pits. Gas was obtained from a plant of 26 Morgan gas-producers. These four furnaces were lengthened in 1915 and became 55-ton furnaces. In 1916 two new 70-ton furnaces were erected with 6 gas-producers, making a total of 32. In 1919 the third 70-ton furnace and one soaking-pit were erected with 7 gas-producers, making a total of 7 furnaces, 39 gas-producers and 4 soaking-pits.

The steel plant is at present capable of producing approximately 19,000 tons of steel ingots per month.

The rolling mills consist of one 40-inch blooming mill, one 28-inch, two high reversing rail mill, with 3 stands of rolls, 4 stands of 16-inch and 6 stands of 10-inch bar mill rolls. The blooming mill is operated by a Galloway 3-cylinder 40″×54″ reversing non-condensing engine, the 28-inch rail mill by an Ehrhardt and Sehmer 3-cylinder $51\frac{3}{8}''\times51\frac{3}{8}''$ reversing non-condensing engine. The bar mills are also operated by steam engines.

[1] Kindly revised by the General Manager, Tata Iron and Steel Company, Limited.

Up-to-date workshops, comprising pipe-, smith-, pattern-, foundry- machine- and structural shops, provide the required material for repairs, maintenance and construction. Twelve broad-gauge locomotives and nine locomotive cranes comprise the transportation and material handling equipment.

The outputs of pig-iron and steel during the five years under review are shown in table 50.

TABLE 50.—*Production of Pig-iron and Steel by the Tata Iron and Steel Co., Ld., during the years 1914—1918.*

YEAR.	Pig-iron.	Steel *including Steel Rails.*	Steel Rails.
	Tons.	Tons.	Tons.
1914	162,282	66,603	45,639
1915	154,509	76,355	16,817
1916	152,460	92,902	36,595
1917	167,870	114,027	72,670
1918	198,064	130,043	71,096
Average .	*167,037*	*95,986*	*48,563*

It is now[1] possible to add also the following figures showing the output of the works for the 12 months ending 30th June 1919 :—

	Tons.
Pig Iron	211,096
Steel Ingots . . .	185,060
Blooming Mill, Blooms, etc.	163,161
28" Mill—	
Rails	66,749
Beams	10,097
Channels	5,508
Angles	3,367
Blooms and Billets . .	7,556
TOTAL 28" MILL MATERIAL	93,277

[1] February 1920.

Bar Mill—

	Tons.
Rails	4,220
Beams	104
Channels	275
Angles	7,713
Tees	743
Fish Plates	3,700
Bars	25,120
TOTAL BAR MILL MATERIAL	41,875

Iron-ores of Mayurbhanj State.

Although the Tata Iron and Steel Company possesses slightly richer and purer ore-bodies in the Raipur district, supplies of ore are at present drawn from the deposits in Mayurbhanj, which are nearer to the site of the works and to which the Bengal-Nagpur Railway Company has built a branch line about 45 miles in length.

The occurrence of valuable iron-ore deposits in Mayurbhanj was first noticed by P. N. Bose,[1] who mentioned the following occurrences :—

(*a*) Bamanghati sub-division—
- (1) Gurumaishini Hill, over an area of 8 square miles.
- (2) Near Bandgaon in Saranda-pir.
- (3) Sulaipat-Badampahar range from Kondadera to Jaidhanposi, a distance of some 12 miles.

(*b*) Panchpir sub-division—

At several places from Kamdabedi and Kantikna to Thakurmunda, a distance of 25 miles.

(*c*) Mayurbhanj proper—

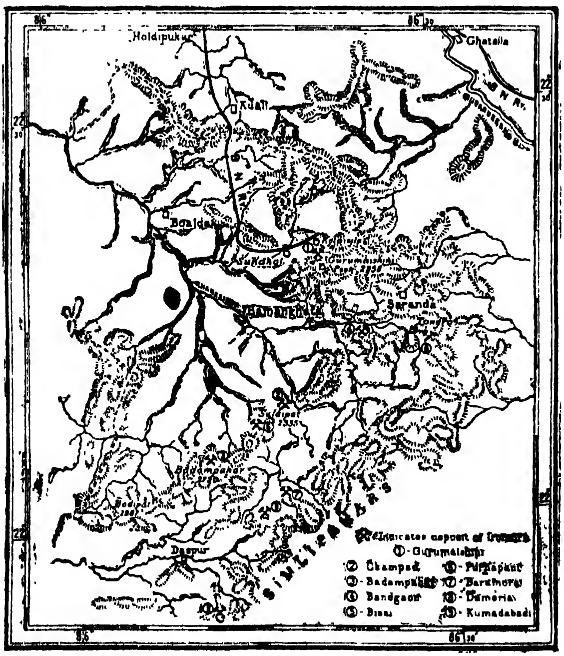
Simlipahar range, and the submontane tract to the east (Gurguria, Kendua, and Baldia).

Subsequently, on the possibility of these ores being suitable for the proposed iron and steel works, they were re-examined by Messrs. C. P. Perin and C. M. Weld, who arranged for detailed prospecting operations after securing prospecting rights from the Maharajah. A subsequent examination of the ground by Mr. W. Selkirk having demonstrated the existence of sufficient ore to warrant operations on a large scale, a lease was granted to the company

[1] *Rec. Geol. Surv. Ind.*, XXXI, p. 168 (1904).

over 12 square miles on a royalty-scale that will work out to an average of 2·62*d*. per ton for the first thirty years and 5*d*. per ton for the next following thirty years, on an annual output of 200,000 tons of ore.

Prospecting operations determined the existence of over a dozen considerable deposits of high-grade ore in the more accessible parts of the State (see fig. 10). Of these deposits three, namely, Gurumaishini, Okampad (Sulaipat), and Badampahar, so far overshadow the others that reference will be made in detail to them alone. The chief point of interest in connection with the smaller deposits is that in every case the nature or type of occurrence is practically identical with the great deposits, they being miniature reproductions as it were of the latter. As the main work of the prospectors has been devoted to the first necessary problem of determining the superficial disposition of the richer ore-bodies, very little has been done so far in the way of studying the geological relations and genesis of the ores.[1]



Scale :—1 inch = 16 miles.

FIG. 10.—*Map showing position of the Mayurbhanj iron-ore deposits.*

[1] We are indebted to Mr. C. M. Weld for the observations summarised below.

The ore-deposits have almost all been found to take the form of roughly lenticular leads or bodies of hematite, with small proportions of magnetite, in close association with granite on the one hand and granulitic rocks on the other. These latter have been noted in the field as charnockites, the term being employed, rather loosely no doubt, but probably in the main correctly, to cover types of rather widely varying acidity. In still more intimate association with the ores than either of the foregoing were found masses of dense quartz rocks, frequently banded, and banded quartz-iron-ore rocks. These last are of the types so commonly associated with Indian iron-ores, but are here not so prominent as is usually the case. Lastly, there exists a net-work of basic dykes certainly cutting the granite and apparently cutting the iron-ores and charnockite. The relative ages of the granite and charnockite have not as yet been determined.

(1) Gurumaishini.

The Gurumaishini hill-mass, with its three prominent peaks, the highest rising to an elevation of 3,000 feet above sea-level, and its numerous flanks and spurs, forms a conspicuous feature in the topography of the northern part of the State. The large bodies of iron-ore found at this point and their accessible position have combined to make it the first point of attack, fifteen million tons of ore have been proved to date, the average composition being :—

	Per cent.
Iron	60·0
Phosphorus	0·082
Insoluble residue	5·83
Manganese	0·42

The following analyses of samples taken in the course of the several examinations to which the deposits have been subjected are also of interest :—

	Iron.	Phos-phorus.	Sulphur.	Silica.
	Per cent.	Per cent.	Per cent.	Per cent.
Average of eleven samples both solid and 'float' ore.	61·85	0·135	0·036	4·08
Average of 20 samples of 'float' ore.	61·46	0·048	0·036	3·34
Average of ten samples of solid ore .	64·33	0·075	0·021	1·64

A number of these samples was put through a complete analysis, thereby proving the absence of titanium, chromium, zinc, nickel, and cobalt (except in one case where 0·090 per cent. was found), copper, lead, and baryta; and the presence of arsenic in traces only (in one case up to 0·008 per cent.).

During the past five years, the Company's supplies of iron ore have been drawn from this deposit. The following tonnages have been despatched:—

	Tons.	cwt.
1914	284,602	12
1915	240,513	5
1916	249,600	19½
1917	273,440	8
1918	338,736	8¼
1919 for 10 months	354,512	...

The average analysis of this ore has been practically the same as that shown by the analysis taken during the original examination of the property.

Owing to the necessity for constantly maintaining a large and increasing output, there has been very little opportunity for any geological work to be done on the deposit. Mining has been carried on along the northern base of the hill for a distance of about 2 miles. This work has shown that the whole northern slope at the base of the hill at least is covered by a blanket of float ore ranging from 2 to 30 feet in thickness. This float rests upon a decomposed granite cut by quartz pegmatite veins and one or two large basic dykes. No solid ore in place has been disclosed at any point in the workings, in spite of the fact that the northern end of two large ore bodies have been worked out for a distance of several hundred feet along their length.

(2) Okampad.

The Okampad ore deposit is situated just west of the Khorka river, where the latter breaks through the Sulaipat-Badampahar range. Okampad is a conspicuous peak, only slightly lower than the Sulaipat peak (2,535 feet elevation) which lies one mile to the south-west of the former. Gurumaishini lies 12 miles to the north-north-east. A representative sample of the ore gave on partial analysis:—Fe, 63·11; P, 0·029; S, *nil;* Ti, *nil,* per cent.

An extension from 13 to 15 miles in length of the Gurumaishini Railway will tap the Okampad deposit when the time comes for its development.

The ore-body occurs as a single great lens, exhibiting at one point a scarp about 300 feet high, and covering a superficial area of some 300,000 or more square feet in plan. There are, besides, two smaller outliers, and about 165 acres of rich float-ore. The immediate associates of the ore are banded quartz-iron-ore rock and a dense blackish quartzite, the latter especially abundant; all these are completely enclosed in what has been referred to in the field-notes as trap. The low-lying country to the north-west is occupied by granite.

Four samples of Okampad ore, taken at two different times and by two different observers, gave the following average analyses :— Fe, 67·65 ; SiO_2, 1·58 ; P, 0·043 ; S, 0·012 per cent.

(3) Badampahar.

The last of three major deposits occupies the Badampahar peak (2,706 feet elevation), in the Sulaipat-Badampahar range, 8½ miles south-west from Okampad. Here again, as at Okampad, a single great lens of ore, roughly figured to be 3,000 feet long by 500 feet broad, with many smaller outliers, occupies the crest of the range, masses of rich float extending for many hundreds of feet downwards. Six hundred vertical feet were measured from the lowest observed massive outcrop to the highest. The immediate associates of the ore were seen to be banded quartzites and quartz-iron-ore rocks, with abundant rather basic holocrystalline rocks referred to charnockite. The lower ground to the north-west is said to be completely occupied by granite. The Bengal-Nagpur Railway is being extended from Onlajori station on the Tatanagar-Gurumaishini branch, a distance of 25 miles, into the Badampahar deposit. This line is now under construction and the Company have begun the erection of their plant at Badampahar.

Pal Lahara State.

During a visit to Pal Lahara State Dr. Fermor obtained specimens from the mountain mass known as Malayagiri (3,895 feet) (which he was unable personally to visit) proving the existence, hitherto unsuspected in this part of Orissa, of hematitic quartzites of Dharwar aspect. Amongst the specimens was some high-grade micaceous hematite, pointing to the desirability of examining this part of Orissa for still another iron-ore field.

Iron-ores of Singhbhum and Keonjhar.

Recent discoveries of iron-ore in the southern parts of Singhbhum have resulted in a large number of applications for prospecting licenses and mining leases, and it was considered advisable that the ferruginous belt should be geologically examined. Mr. H. C. Jones, who has been engaged on this investigation has found that the iron-ore occurs usually at or near the tops of hills, the most important being the range running from about 3 miles south-west of Gua to the Kolhan-Keonjhar boundary east of Naogaon, *i.e.*, a distance of about 10 miles. The range, which rises some 1,500 feet above the plain, is said also to continue into the Keonjhar and Bonai States. Mr. Jones found that good iron-ore formed the top of this range of hills almost without a break. Parallel to this range is another similar line of hills running from the Duargui stream, three miles east of Bada, to the Karo river south-east of Ghatkuri, a distance of about 7 miles. Here the iron-ore was found to occupy the top of the ridge as before, the ore in the southern part being apparently as good and continuous as in the adjoining range; towards the north, however, a considerable amount of folding and faulting was observed and replacement did not appear to have gone so far. To the west a third range of hills runs from the Karo river, east of Salai, to the east of Chota Nagra. Here also iron ore is found at or near the top of the range, but it appears to be confined to patches, which, however, are of considerable importance. To the east and west of these ranges, again, are more irregular patches of ore occupying the tops of hills. Large quantities of float and lateritoid ore usually occur with the ore bodies.

The Kolhan hematites usually appear to contain about 64 per cent. of iron, with phosphorus ranging from 0·03 to 0·08, or, in some cases, to as high as 0·15. The sulphur content is usually below 0·03. Titanium in very small quantities is also said to be found occasionally in the ore. Samples from the better parts of the ore-deposits contain as much as 68 or 69 per cent. iron. Comparatively little prospecting work on the deposits has been done hitherto by concessionaires but enough is known to justify the belief that the quantities of ore available will run into hundreds—possibly into thousands—of millions of tons. In most cases, the chief obstacle to development lies in the difficult and inaccessible nature of the country, but a branch of the Bengal-Nagpur Railway

is now being constructed from Amda to Jamda in order to tap some of these ore bodies.

Mr. Jones states that the rocks of the area consist chiefly of shales or slates, and phyllites with bands of chert, sandstone, quartzite and banded hematite-quartzite. Thin bands of siliceous limestone are occasionally found. The banded hematite-quartzites are important as forming the main part of the iron-bearing series. Being extremely hard and consisting largely of insoluble iron oxide, they resist weathering and stand out, forming most of the high hills and ridges in the country examined. Dykes and inter-bedded layers of greenstone are common. According to Mr. Jones the sequence of rocks in which the iron-ore occurs appears to be :—

(1) newer slaty shale ;
(2) banded hematite quartzite ;
(3) older slaty shale.

Above the newer shale Mr. Jones found a band of conglomeratic breccia, which he refers tentatively to the base of the Cuddapah system. Of the ferruginous rocks the commonest type consists of interbanded layers in varying proportions of iron oxide, silica and combinations of the two. The silica is sometimes crystalline and sometimes cherty. The chert, however, is not truly amorphous, but consists of fine interlocking quartz grains. At times the silica is red and jaspideous. The iron oxide is usually hematite, but octahedra of magnetite are sometimes found. According to Mr. Jones, the ore-bodies are the result of the local enrichment of the hematite-quartzites and sometimes of the ferruginous shales, largely by the leaching out of silica, and to a less extent by the introduction of iron oxide.

Iron-ores of the Drug district, Central Provinces.

The occurrence of valuable iron-ores in the Raipur district was not appreciated before Mr. P. N. Bose briefly referred to the chief deposits in a paper published in these *Records*, Vol. XX, page 167 (1887). The district having been explored again on behalf of Messrs. Tata Sons & Co., by Mr. C. M. Weld, a large area in the Dondi-Lohara *zamindari*[1] in the western part of the district was taken up under prospecting license for detailed examination.

[1] This portion of the Raipur district has been included in the new district of Drug formed in 1906.

The iron-ores, on account of their resistance to weathering agents, stand up as conspicuous hillocks in the general peneplain. The most striking of these is the ridge which includes the Dhali and Rajhara hills, extending for some 20 miles in a zigzag, almost continuous line, and rising to heights of sometimes 400 feet above the general level of the flat country around. The iron-ores are associated with phyllites and are often of the usual type of banded quartz-iron-ore schists characteristic of the Dharwar system. But in places thick masses, apparently lenticular in shape, are formed of comparatively pure hematite, and one of these in the Rajhara hills has been subjected to very careful examination by diamond drilling. The Rajhara mass was carefully sampled across the surface at each point selected for a drill hole and the cores obtained were also analysed in lengths representing successive depths of 10 feet each from the surface, giving altogether 64 samples which were assayed for iron, phosphorus, sulphur, silica, and manganese. The average results obtained for the surface samples were as follows:—Fe, 66·35; P, 0·058; S, 0·108; SiO_2, 1·44; Mn, 0·151 per cent.; while for the cores the averages were:—Fe, 68·56; P, 0·064; S, 0·071; SiO_2, 0·71; Mn, 0·175 per cent.

In this mass the prospecting operations thus proved the existence of 2½ million tons of ore carrying about 67·5 per cent. of iron and a phosphorus content only slightly below the Bessemer limit. The quantity estimated is that which may be regarded as ore in sight while almost certainly much larger quantities may be obtained by continuation of the ore-bodies beyond their proved depth. There are other large bodies of ore in this area which have not been examined in the same detail. These masses of hematite include small quantities of magnetite, but separate determinations of the iron in the ferric state have not been made in order to determine the relative proportions of the two minerals.

Iron-ores of the Jubbulpore district.

In addition to the results of prospecting operations conducted for the Tata Iron and Steel Company in Mayurbhanj and the Central Provinces, valuable information has been collected by Mr. E. P. Martin and Professor H. Louis in the Jubbulpore district. Prospecting operations conducted in this area showed that while iron-ore is widely distributed and the formations in which it occurs are prominent in the district, there are no rich ore-bodies of large

size that could be relied on for the output necessary to maintain an important industry, and most of the ore, being in the form of soft micaceous hematite, would be physically unfit in its natural condition for use in a blast furnace. Generally, also, the ores in this district contain a proportion of phosphorus too high for acid Bessemer steel.

The following analyses, extracted from Messrs. Martin and Louis' report (*Agricultural Ledger*, Calcutta, 1904, No. 3), give an idea of the nature of the ore in the principal occurrences in the Jubbulpore district :—

TABLE 51.—*Assays of Jubbulpore Iron-ores.*

——	Iron.	SiO_2.	S.	P.	Moisture.
I. *Agaria hill.* Lateritic cap covering most of the hill. 3 samples.	57·58 56·85 45·67	7·28 8·17 13·90	0·02 0·02 0·03	0·125 0·125 0·187	0·45 0·67 0·69
Soft micaceous hematitic schists. Ore-layers only. 2 samples.	60·70 58·40	7·45 8·40	0·019 0·022	0·075 0·081	0·25 0·33
II. *Agaria ridge.* Bed of hematite 4 to 5 feet thick, dipping 50°.	50·07	11·37	0·036	0·074	0·44
III. *Jauli.* Soft, banded hematite-quartz schists. Picked samples.	64·67 54·64 65·50 55·22	3·70 16·05 3·37 17·32	0·027 0·033 0·032 0·030	0·023 0·200 0·110 0·053	0·30 0·48 0·33 0·21

Near Sihora siliceous brown hematites were found, poorer in iron but physically more suitable for the blast furnace, and in this area there occur patches of manganiferous iron-ore. The following analyses were obtained from samples obtained at Mansakra (Silondi) near Sihora :—

——	Fe.	Mn.	SiO_2.	S.	P.	Moisture.
Wider band . . .	52·15	0·36	14·70	0·022	0·385	0·10
Narrower band . .	44·95	6·28	14·55	0·027	0·352	0·27
Manganiferous iron-ore .	24·45	21·47	19·60	0·022	0·163	0·80

Mysore.

Iron-ores are known to occur in large quantities in the Mysore State, and have been investigated by the Mysore Geological Department. We are indebted to Dr. W. F. Smeeth for the following notes :—

The ores appear to belong to various phases of the Archæan complex and to differ considerably in their modes of origin. The hematite ores of the Bababudan Hills are by far the most abundant and are of good quality, but vary considerably in the amount of phosphorus that they contain. The following classification seems to be in accordance with the numerous observations so far recorded :—

(1) Banded ferruginous-quartz rock which occurs as a common integral component of the Dharwar schists. The banded ferruginous-quartzites are very widely distributed and vary greatly in the respective proportions of magnetite and hematite present. A number of samples from the scarps of the Bababudan Hills gave averages of 38 per cent. and 42 per cent. of iron, but many of the outcrops contain less. Owing to the very intimate admixture of the quartz and iron-ore grains in these rocks magnetic concentration has not proved very successful. Fine crushing is necessary but even after crushing through 60 mesh the richer concentrate (Fe=64 per cent.) contained only 35 per cent. of the iron in the rock. With stronger magnetic field between 60 and 70 per cent. of the iron can be recovered in a concentrate assaying about 60 per cent. Fe. The following analyses represent averages of a large number of samples divided for convenience into three grades. The analyses are made on dried ores. The moisture is usually under 1 per cent.

—	High grade.	Medium grade.	Low grade.
	Per cent.	Per cent.	Per cent.
Loss on ignition	5·23	8·87	10·61
SiO_2	1·12	1·96	3·62
Al_2O	2·36	3·60	9·42
TiO_2	Tr.	Tr.	0·20
Mn	0·10	0·13	Tr.
Fe	64·24	58·66	53·85
S	0·038	0·038	0·03
P	0·031	0·038	0·05

(2) Desilicified portions of (1) with, in some cases, addition of iron from solution or by metasomatic replacement of quartz and silicates. These form rich hematite and limonite ores. The banded ferruginous-quartzites are usually steeply inclined, but sometimes lie nearly horizontal. This latter is the case over the eastern portion

of the Bababudan Hills, where these rocks form an undulating capping of from 200 to 500 feet in thickness on top of the greenstones and hornblende schists at an elevation of about 5,000 feet. In this area the banded quartzites outcrop where there are sharp local folds or crumples or where there has been much denudation. On the more gentle dips and undulations solution of the silica has been active and has caused the removal of the quartz to a depth of many feet. The result is the production of a more or less banded and porous layer of hematite ore to a variable depth, in places 10 feet and probably deeper. A sample taken to a depth of 9 feet gave the following analysis:—

Moisture at 100°C. = 0·36 per cent.
On ore dried at 100°C.

H_2O	6·00	Fe	58·37
Fe_2O_3	82·79	P	0·057
FeO	0·54	S	0·047
MnO	0·08		
Al_2O_3	9·82		
MgO	0·26		
CaO	0·13		
SiO_2	0·77		
P_2O_5	0·13		
SO_3	0·118		
	100·638		

(3) Zones or layers of massive ore,—probably the result of the metasomatic replacement of silicates (igneous and metamorphic schists) by oxides of iron. These are either limonites or hematites and are sometimes associated with (1) and sometimes not. In some places they are associated with manganese-ores. Such ore-bodies have been found amongst the steeply inclined schists of the Shimoga district and also in the Chitaldrug schist belt, in both cases near or adjacent to manganese-ores. As regards quantity, there can be no doubt that a very large supply of fairly good ore can be obtained from various points on the eastern section of the Bababudan Hills, but no satisfactory estimate would be possible without extensive prospecting.

Of ores containing about 64 per cent. iron a few million tons could probably be obtained, but it is questionable whether it would be worth while to pick such a high grade in iron. Of ores running about 60 per cent. iron probably some 25 to 50 million tons could be obtained in several large deposits, and of lower grade ores, down to 55 per cent. iron, the quantity might safely be put at 100 millions and probably at several times this amount.

(4) Magnetite and hematite lenses which appear to be of magmatic origin associated with ultra-basic rocks intrusive into the Dharwar schists. They are usually highly titaniferous.

A number of long lenticular outcrops of these iron-ores have been found in the Channagiri Taluk. The ores from a large number of outcrops have a strong family resemblance, and of the more massive varieties several hundred thousand tons are easily available. Partial analysis of a number of samples showed that the ores

were all very similar, and a more complete analysis of one gave the following:—

	Per cent.
H_2O (total)	1·23
SiO_2	0·88
Fe	56·82
S	0·049
P	*Nil*
MnO	0·48
Cr_2O_3	3·09
Al_2O_3	1·79
CaO	0·72
MgO	1·58
TiO_2	11·60

The large amount of titanium spoils these ores for smelting purposes. The absence of phosphorus and the presence of chromium are features of all the samples. Some ores of this series also occur in the Nuggihalli schist belt of the Channarayapatna taluk, where they are closely associated with chrome ores in a series of amphibolites and peridotites.

(5) Quartz-magnetite ores, which appear to be of magmatic origin and genetically related to the charnockite series and therefore subsequent to the Dharwar schists and to the Archæan gneiss. These ores occur in the Malvalli taluk north of the Cauvery river, where the charnockite masses of Kollegal penetrate the older gneiss and schists in tongues and dyke-like intrusions. They are found also in parts of the Mysore district.

Numerous gradations have been observed between the normal basic charnockite and these ores, in which we get increases in the proportion of the magnetite and quartz with diminution of the felspar and ferromagnesian constituents, and finally a rock composed essentially of quartz and magnetite with a little accessory hypersthene, amphibole, or garnet. The rock occurs in long thin lenses or dykes in the more normal charnockites or in the older gneissic complex, and the constituent minerals are usually granular without any marked tendency to a banded arrangement.

Iron Works.

The Mysore Government are now erecting a chemical blast furnace at Benkipur in the Shimoga district to smelt some 20,000 tons of pig iron from the ores mentioned in section (3).

A modern American furnace is being erected capable of producing 50 tons or more of pig per day. A large by-product wood-distillation plant capable of dealing with 120 maunds per day is also being provided. About 120 miles of narrow gauge tram lines are being laid through a large area of forest to bring in the necessary wood and iron-ore. About 100,000 tons of wood will be required annually for the charcoal plant.

The smelting plant and distillation works are being designed and erected by Messrs. Perin and Marshall of New York City, and will

be under the management of the Tata Iron and Steel Co., who will act as agents for the Mysore Government under control of a Board of Management.

The iron-ore will be obtained largely from Kemmangundi on the Bababudan Hills and will be mined and supplied under the direction of officers of the Government Department. An aerial ropeway, with a capacity of 40 tons per hour, will convey the ore from the mine to the foot of the hills—a distance of 1½ miles with a drop of 1,850 feet. It will there be fed into tramway wagons and hauled to Benkipur a distance of 25 miles.

Flux will be obtained from Kohlapur in the Tumkur district, and may be either a dolomite carrying 1½ per cent. of insoluble or a limestone carrying 49-50 per cent. of CaO and 5 or 6 per cent. of insoluble.

Owing to high prices for materials and labour, the cost of the scheme including tramways, is likely to be about Rs. 120 lakhs.

Goa and Ratnagiri.

In 1912 a visit was paid to certain iron-ore deposits being opened up by the Compagnie des Mines de Fer de Goa in the Portuguese territory of Goa, and by Messrs. Jambon & Co in the adjoining British district of Ratnagiri.[1] The iron-ore of these localities is of Dharwar age and crops out in the midst of laterite, and, as seen at the outcrop, is a hard ore composed either of limonite or of hematite containing minute crystals of magnetite. At Bicholim in Goa the principal ore band has been traced for a distance of 7 kilometres and is said to vary in width from 30 to 100 metres. Such work as had been carried out in 1912 indicated that this hard ore is probably the surface hydrated form of friable schistose micaceous hematite, which is found unaltered at a relatively small distance, approximately 50 feet, below the surface. On account, however, of the extent of the outcrops, the hard superficial ore is probably available in large quantities, and, as analyses indicate it to be of high grade, with a very low percentage of silica, and phosphorus below the Bessemer limit, it seems probable that Goa possesses valuable iron-ore reserves. Some of the deposits are only 4 miles from navigable water and it is therefore not impossible that the company may succeed in their project of mining iron-ore for export to Europe. The mining of the friable schistose hematite, when the surface ores are exhausted, will be another problem and will depend for its success on the

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XLIII, p. 18 (1913).

discovery of a cheap and easy method of bagging or briquetting. The iron-ore deposits near Redi in the Ratnagiri district are very similar to those of Bicholim and may also when opened up prove to be of considerable size.

The native smelting industry.

The indigenous methods of smelting iron have been frequently described for various districts in India, and no new features in the methods have recently been noticed. The industry still persists in a few districts of Bengal and Bihar and Orissa; in the Kumaon hills; in Mysore; the districts of Malabar, Salem, and Trichinopoly of Madras; in Hyderabad, and in several States in Central India and Rajputana. The industry shows signs of greater activity in the Central Provinces than elsewhere, but there has been a very marked falling off during the period under review. Returns are now only partial and have been received from only four districts, of which the most important were Bilaspur and Raipur as will be seen from table 52. At one locality, Ghogra, in Jubbulpore district, manganiferous iron-ore is smelted with production of a steely iron known as *kheri*.[1]

TABLE 52.—*Number of Iron-smelting furnaces at work in the Central Provinces during the period 1915-1918.*

DISTRICT.	1915.	1916.	1917.	1918.
Balaghat	(*a*)	4	3	(*a*)
Bilaspur	108	102	103	131
Drug	49	41	52	101
Raipur	150	162	157	(*a*).
TOTAL	307	309	315	232

(*a*) Figures not available.

The native smelting industry in Garhwal.

Iron-ore occurs at numerous places along the outer Himalaya, the rocks being similar lithologically to some of the Dharwars of Peninsular India. Owing to the abundance of timber and, until recently, the absence of railway transport by which cheap foreign iron and steel have been distributed, the *lohar*, or *agaria* as the native smelter is sometimes called, flourished to a later date than in the more accessible parts of the Peninsula, and the industry of iron-smelting still persists in a languishing condition. The necessity of curtail-

[1] *Mem. G. S. I.*, XXXVII, p. 595.

ing the indiscriminate cutting of forests, the readiness with which a large variety of foreign implements can be obtained in the bazars, and the higher wages obtainable on account of the general progress of the country have all combined to encourage the *lohar* to leave his ancestral calling for other industries, although a few workers still occupy their leisure during slack seasons in smelting, and the native-made product is preferred to foreign iron when it can be obtained readily.

In the higher parts of the Garhwal district the fuel used is the charcoal of the *buran* (rhododendron) and *ayas* (oak), while the *chir* tree (*Pinus longifolia*) is used in the lower hills. The simple 'bloomeries' used are not unlike those generally used on the plains. The purified wrought iron obtained from about one maund (82 lbs.) of ore weighs only about 10 lbs. which, when made up into rough implements like hoes, hammers, and crowbars, sells at about Rs. 3-12, and to produce this amount labour and charcoal (1½ maunds) to the cost of Rs. 2-2 are required.

The *lohars* of Garhwal are regarded as belonging to an upper section of the low-caste *doms*. They regard as the founder of their caste one Kaliya *lohar*, who is supposed to have supplied the Pandavas with their fighting weapons, and he is now propitiated before each smelting operation with an offer of five pieces of charcoal.

Imports.

Except for the pig-iron and steel produced at Barakar and Sakchi, practically all the iron and steel used in India is imported; the steel furnaces in the Government Ordnance factories and in the East Indian Railway works at Jamalpur are supplied mostly with scrap steel and imported pig, while the iron produced by indigenous methods probably amounts to less than 1,000 tons a year. The imports of pig iron averaged 23,425 tons a year during the five years 1914-1918, as compared with an annual average of 13,130 tons during the preceding five years. The requirements of the country in iron and steel are indicated by the import returns summarised in table 53. From this it will be seen that the total value of the unfinished and finished iron and steel products imported into India fell from a little over 26¼ million pounds in 1914 to under 12 million in 1917; there was a marked increase again in 1918. Although the reduction in imports may be due in a small degree to increased production in India, it is, of course, to be attributed mainly to the effects of the war.

TABLE 53.—*Imports into India of Iron and Steel materials during the years 1914 to 1918.*

—		1914.	1915.	1916.	1917.	1918.	*Average.*
Cutlery and hardware	£	2,560,716(*a*)	1,855,856	2,602,901	2,361,399	2,425,817	*2,361,338*
Machinery and mill-work	£	4,877,254(*a*)	3,293,544	3,773,962	3,171,738	2,887,357	*3,600,771*
Railway plant and rolling stock . .	£	9,939,482(*a*)	5,047,250	1,594,210	535,504	960,138	*3,615,317*
Iron bars, pig-iron, etc. . . .	£	274,204	238,406	403,105	438,465	233,851	*317,606*
	Tons.	33,684	25,989	25,120	22,497	9,836	*23,425*
Iron and steel beams, sheets, pillars, rivets, etc.	£	7,276,789	5,196,734	5,003,957	4,888,314	5,289,928	*5,531,144*
	Tons.	630,472	365,412	232,360	151,971	122,149	*300,473*
Steel bars, angle and channel, ingots, blooms, billets, etc.	£	1,361,937	775,552	656,646	437,519	1,679,264	*982,184*
	Tons.	205,821	73,464	39,726	17,437	34,267	*74,143*
TOTAL value .	£	**26,290,382**	**16,407,342**	**14,034,781**	**11,832,939**	**13,476,355**	***16,408,360***

(*a*) Figures for quantities not available.

Jadeite.

[E. H. PASCOE.]

Exports.

The mineral jadeite, like the true jade (nephrite) with which it is often confused, is especially prized by the Chinese, especially by carpenters and other workmen who believe that the wearing of jade bangles renders them immune to accidents. The quarrying of the mineral forms quite an important industry in Upper Burma. Some of the mineral raised passes by the overland route into South-West China (Yunnan), but most of it finds its way down to Rangoon, whence it is exported to the Straits Settlements and China. Table 54 shows the extent of this export trade. From this it will be seen that the average annual export during the period under review was 4,651 cwts., as compared with an average figure of 4,700 cwts., for the period of the previous review.

Prices.

The prices paid for rough stone vary too much to permit of an average figure being given, but the export values declared give an idea of the worth of the stone; from table 54 it is seen that the value so determined has averaged £16·02 per cwt. during the period under review, being an increase of 12 shillings and nine pence per cwt. on the average price during the preceding period of five years. From 1914 to 1918 the amounts exported show a general decrease, which is, however, more than compensated by a rise in the quality of the stone.

TABLE 54.—*Exports of Jadestone from Burma for the years 1914-15 to 1918-19.*[1]

YEAR.	Weight.	*Value.*	Value per cwt.
	Cwts.	£	£
1914-15	4,971	*67,052*	13·49
1915-16	5,202	*46,380*	8·91
1916-17	6,136	*81,659*	13·31
1917-18	3,609	*85,944*	23·81
1918-19	3,336	*91,456*	27·41
Average	*4,651*	*74,498*	*16·02*

[1] Overland trade and exports *viâ* Rangoon combined.

Value of jade.

Amongst prehistoric relics found in various parts of the world, both nephrite and jadeite implements and ornaments are widely distributed, and an admiration for the beauty of the stone, descended from a belief in its magical properties, maintains the value of the mineral in the eyes of the Chinese, who are the chief buyers. A workman, for instance, wearing a bracelet of jade, is supposed to be immune from the danger of falling off a ladder. To the Chinese the different varieties of both minerals, and possibly some others, are known under the generic name *yu-esh.* The softer, serpentinous mineral, bowenite, passes on the North-West Frontier under the name of *sang-i-yeshm,* and though its characters are unmistakably distinct from those of nephrite and jadeite, it is evidently regarded as a poor variety of jade.

Composition.

Two distinct minerals are included in the term jadestone or jade, namely, the true *jade* or *nephrite,* which is a silicate of calcium and magnesium, $CaO.3MgO.4SiO_2$, and a member of the amphibole group: and *jadeite,* which is a pyroxene of the composition $Na_2O.Al_2O_3.4SiO_2$ (silicate of sodium and aluminium). They are very similar in colour and other physical properties, but jadeite is slightly the harder and considerably the heavier of the two, and is more fusible. They are prized equally by the Chinese. No jade (nephrite) of the kind that would be regarded as a marketable mineral is known in India; but a mineral, having the essential composition and approaching coarse jade in physical characters, is known in South Mirzapur.[1] True jade, however, has been largely worked in the Karakash valley in South Turkestan for many centuries.[2]

Mode of occurrence.

The only jadestone of commercial value found in the Indian Empire is the jadeite found in the basin of the Uru river, a tributary of the Chindwin, in the Mogaung sub-division of the Myitkyina district, Upper Burma. Jadeite is now worked at three localities—Mamon, Hweka, and Tawmaw (25° 44′; 96° 14′). At *Mamon* the jadeite is found in the form of boulders in the alluvial deposits of the Uru river, and also in the bed of the river itself. At *Hweka* the mineral is found in the form of boulders in a conglomerate of Tertiary age. But the most interesting of the three occurrences is at *Tawmaw.* Here similar

[1] F. R. Mallet, *Rec. Geol. Surv. Ind.,* V, p. 22 (1872).
[2] *Cf.* papers quoted by Mallet in Manual, Geol. of Ind., Part IV, p. 85 (1887).

boulders of the stone embedded in yellow or orange coloured clay were described by W. Griffith in 1847. It was recovered from pits about 20 feet deep and yielded an annual revenue in 1836 of something like Rs. 40,000. Subsequently it was found *in situ* in this area. Dr. A. W. G. Bleeck[1] describes the jadeite of Tawmaw as occurring in a metamorphosed igneous dyke intruded into serpentine. He concludes that the jadeite is the result of the metamorphism of an albite-nepheline rock originally forming the dyke. The change would be represented chemically as follows:—

$NaAlSiO_4$ (nepheline)+$NaAlSi_3O_8$ (albite)=$2NaAlSi_2O_6$ (2 jadeite).

Under certain conditions of crystallisation nepheline-albite rocks might be formed, while under conditions of high pressure, during consolidation or after, jadeite, which has a much lower molecular volume, would be produced, the residual molecule forming albite or nepheline, according to which molecule was in excess in the original magma. (The albite molecule was the one in excess; for this mineral occurs in a mixed zone of albite and jadeite on each edge of the dyke.) The serpentines form a long ridge flanked on either side by saussuritic gabbros, saussuritic glaucophane-schists, and chlorite-schists. These rocks are traversed by granite and veins of quartz; all the rocks are regarded as genetically related and as the results of the differentiation of the same magma, which gave rise successively to the peridotites, gabbros, nepheline-albite (jadeite) rock, and the siliceous end-products—granite and quartz.

History of the jadeite trade.

The following notes on the history of the jadeite industry are taken from a copy of the chapter on the jade-mining industry prepared for the Myitkyina District Gazetteer by Mr. W. A. Hertz, and kindly supplied by the Government of Burma. This in its turn is largely based on a report by Mr. Warry of the Chinese Consular Service written in 1888, and is so interesting that a perusal of the full chapter in the Gazetteer[2] will well repay the reader for the time spent. In the following paragraphs the term *jade* is used in its generic sense, referring in the case of Burma to jadeite.

According to Mr. Warry, jadestone or nephrite has been known in China from a period of high antiquity. It was found in Khotan and other parts of Central Asia, the most valued variety being the costly milk-white kind held in high esteem as symbolical of purity

[1] 'Jadeite in the Kachin Hills,' *Rec. Geol. Surv. Ind.*, XXXVI, pp. 254—295 (1908).
[2] Vol. A (1912), pp. 104—119.

in private and official life. The discovery that green jade (jadeite) of fine quality occurs in Northern Burma was made accidentally by a small Yunnanese trader in the thirteenth century, who, to balance the load on his mule, picked up a piece of stone, which was later found to be jade of great value. For some centuries small pieces of stone found their way across the frontier, but it was not until 1784, after protracted hostilities between Burma and China, that a regular trade was opened between the two countries, and then the Chinese soon discovered the position of the jade-producing district. At the beginning of the nineteenth century the Burmese kings seem to have become aware of the importance of the jade trade and the revenue it might yield, and in 1806 a Burmese Collectorate was established at the site of what is now the town of Mogaung, which became the head of the jade trade in Burma. The Kachins, in whose country the jade deposits are situated, and who were regarded as the absolute owners of all the jade produced, brought the mineral to Mogaung, where it was sold to the Chinese. When it was ready to leave Mogaung an *ad valorem* duty of 33⅓ per cent. was levied and a permit issued. Payments were made in bar silver—at first fairly pure, but later on debased with lead (rupees did not come into general use until 1874).

The period of greatest prosperity of the jade trade was 1831-1840, during which time at least 800 Chinese and 600 Shans were annually engaged in business and labour at the mines. All the stone went by one of several routes to Yunnan-fu, then the great emporium of the jade trade, where Cantonese merchants bought the rough stone and carried it to Canton to be cut and polished. In 1841 war broke out between Great Britain and China and the hostilities at Canton soon affected the jade trade, so that the Cantonese merchants ceased to go to Yunnan-fu, to buy stone. Stocks accumulated and Yunnan traders ceased visiting the mines. The trade passed through various vicissitudes, but it was not until 1861 that it really improved again. From that date, when the first Cantonese merchant arrived in Mandalay and made a fortune by buying up all the old stocks of jade, till now, the bulk of the stone has been carried by sea to Canton. During the ensuing years, the jade dues were sometimes collected in the orthodox way—by the Collector at Mogaung—whilst in other years the tax was farmed out; but the King of Burma, dissatisfied with the revenue thus

obtained from jade, tried in some years to purchase all the material himself direct from the Kachins at the mines. In such years the Kachins, preferring the former revenue methods, curtailed the output and produced pieces of inferior quality only. The revenue accruing to the King from the jade dues varied from Rs. 10,000 per annum to Rs. 50,000, being least when the King tried to purchase the jade himself. With the British occupation of Upper Burma the tax was farmed out to Leonpin, who made himself so unpopular by his methods of collecting the tax that he was murdered at Mogaung. The first British visit to the mines was made in 1888 by Major Adamson with a column of British troops. The tax of $33\frac{1}{3}$ per cent. on output is still farmed out by Government. It is collected at Mogaung in the case of stone transported on mules *viâ* Kamaing, and at Kindat in the case of stone transported on bamboo rafts down the Uyu and Chindwin.

The amounts realised on account of this farm during the period under review are shown below :—

1914-15	27,190	rupees per annum
1915-16	48,200	,,
1916-17	85,500	,,
1917-18	95,100	,,
1918-19	95,000	,,

The farm includes also the right to collect the royalty on *amber* at 5 per cent. *ad valorem* in the Myitkyina and Upper Chindwin districts. This system is particularly pernicious and is one which readily lends itself to abuses, it being to the interest of the lessee of the royalty as well as to that of the producer to keep the returns of production as low as possible; and it is probable that much material is smuggled away, thus escaping the payment of royalty.

The official returns for jadeite are anomalous and no reliance can be placed thereon. The fact that the export values are higher than the production values is due largely to the increased value of the mineral after it has been cut, but, in spite of a considerable loss in cutting, the quantities exported are actually higher than the reported amounts produced. The jadeite mines lie in more or less unadministered territory, so that the figures for production are approximate in rather a wide sense; the export figures are a fairly reliable indication of the state of the industry.

In addition to the export duties collected by Government, various dues are levied at the mines by the *Sawbwa* of Kansi, who is the headman of the jade tract.

The actual work of quarrying is carried out by the Kachins during the dry months of the year. At Tawmaw, where the rock occurring *in situ* is quarried, considerable difficulty is experienced in extracting the tough rock, and it is found necessary to resort to splitting by fire, it is said to the detriment of the stone. The use of explosives and also of pumps is, however, being adopted, but the industry has been in a moribund condition for some time and unless steps are taken to revive it and to place it on a more satisfactory basis, it will probably continue to decline.

Jadeite has been found in the Mawlu township of the Katha district, Upper Burma, and is also reported from Tibet. Jade is stated to occur in the corundum quarries of Pipra, Rewah State.

Lead and Silver.

[J. COGGIN BROWN.]

The history of the lead and silver industries in India during the quinquennium 1914-1918 is for all practical purposes the record of the development and expansion of mining and metallurgical operations at the Bawdwin mines in the Northern Shan States. The preceding period witnessed the foundation of the new industry with the production of 46,000 tons of lead and 400,000 ounces of silver in the years 1909-13; during the period now under review, in spite of difficulties of every description caused by the war, 73,817 tons of lead and over 4,831,000 ounces of silver were extracted by the Burma Mines Limited. These products were valued at more than £2,471,000.

Burma: Bawdwin.

Operated by the Yunnanese Chinese for centuries, this great deposit was abandoned by them about 50 or 60 years ago, partly on account of the fact that their primitive methods were of little avail below permanent ground-water level, and partly by reason of political troubles. Modern development was begun in 1902. In 1909, the first production of lead and silver, mainly from old slags left by the Chinese, was made. In 1914 the control passed into the hands of the present owners, the Burma Corporation, Limited, to whom we are indebted for the following note:—

Extensive development has been performed on both the Chinaman and Shan lodes with very satisfactory results.

A new feature has developed during the opening up of the Shan lode to the north. High-grade silver-copper ore has been found in a number of bodies, which now aggregate 305,829 tons of 10·9 per cent. copper ore carrying 23 ozs. silver per ton.

Tiger Tunnel has been now driven to a distance, which is a few hundred feet short of two miles from the portal at Tiger Camp. It is double-tracked for a distance of 7,700 feet and equipped with electric haulage, which conveys the ore in trains of four-ton cars to the electric tipple at Tiger Camp, from which it passes by belt conveyor to the 3,000 ton loading bins.

A large compressor plant has been installed at Bawdwin, capable of delivering 4,100 cubic feet of air at 90 lbs. pressure.

The mine is now fully developed and equipped to handle a large tonnage.

A new concentrating mill will be completed early in 1920, and the power for operating this will be supplied from a hydro-electric scheme at the Mansam falls, about 24 miles from Namtu.

It is also the intention of the Company to erect a modern treatment plant on a new site, a short distance from the existing plant.

The ore reserves as at July 1st, 1919, were as follows :—

—	Tons.	Ag.	Pb.	Zn.	Cu.
	Ozs.	Per cent.	Per cent.	Per cent.	Per cent.
Total Chinaman lode	4,208,125	25·0	27·6	19·1	0·5
Total Shan lode	427,304	20·2	15·6	12·3	0·6
Burman lode	19,385	20·5	24·7	15·8	0·4
Kachin lode	2,070	23·3	6·6	1·5	7·9
Grand total before extraction . .	4,656,884	24·5	26·4	18·4	1·1
Extraction	283,072	32·3	34·3	22·4	0·6
Ore reserve in mine	4,373,812	24·0	25·9	18·2	1·1
Ore stock	75,541	21·9	23·2	20·9	0·3
Total ore reserve	4,449,353	24·0	25·9	18·2	1·1
Less copper ore of July 1st, 1919 .	305,829	23·0	13·2	8·1	10·9
Lead-zinc ore	4,143,524	24·0	26·8	18·9	0·4

TABLE 55.—*Production of Lead and Silver from Bawdwin Ore and Slag during the years 1914 to 1918.*

	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons	£	Tons.	£	Tons.	£
Lead-ore	8,769	...	4,094	...	8,839	...	54,616	...	50,679	...	25,399	...
Slag	24,901	...	32,534	...	4,771	...	6,282	...	2,042	...	14,106	...
Gossan flux	...	...	5,620	...	202	...	10,589	...	9,257	...	5,134	...
Secondaries	...	...	...	...	...	...	...	...	425	...	...	...
TOTAL	**33,670**	...	**42,248**	...	**13,812**	...	**71,487**	...	**62,403**	...	**44,639**	...
Lead extracted	10,548	*202,279*	13,522	*316,077*	13,790	*428,065*	16,962·13	*395,803*	18,994·95	*450,123*	14,763·41	*358,469*
Silver extracted (ounces)	236,446	*26,896*	284,875	*31,099*	759,012	*88,552*	1,580,557	*237,083*	1,970,614	*295,592*	966,301	*135,844*
TOTAL	...	*229,175*	...	*347,176*	...	*516,617*	...	*632,886*		*745,715*	...	*494,313*

In 1918, 18,995 tons of lead and 1,970,614 ounces of silver were produced, and it is estimated that when extensions to the dressing, smelting and refining plants now in hand are completed, the annual outturn will be :—refined lead 31,500 tons ; silver 2,475,000 ounces ; zinc concentrates about 25,000 tons.

Papers dealing with the geology and ore-deposits of the mine have recently been published by H. M. Loveman,[1] and by J. Coggin Brown.[2]

From these reports it is gathered that the minerals of commercial value are galena, zinc blende and chalcopyrite. The ore occurs as solid masses of sulphide, with practically no gangue, in veins of various dimensions, in small stock nodules, and as an impregnation of decomposed rhyolite tuff. The principal deposit is the Chinaman ore-body, which has been developed for considerably over 1,000 feet and varies in width from a few feet to over 100 feet, maintaining on some levels an average width of 50 feet for over 1,000 feet along its strike. "It is primarily a zinc-lead-silver ore-body[2] with small amounts of copper along the edges. Some of the diverging seams and faulted portions of the Chinaman lode are, however, variable in their metal content, showing rapid alterations from zinc-lead to copper-ore and *vice versâ.* These changes take place horizontally and vertically, sometimes as a gradual transition, sometimes marked by a fault plane. A cross section through the Chinaman lode shows a central core of solid zinc-lead ore, with the zinc generally, but not invariably, in excess of the lead. On both sides of this central core are alternating bands of solid ore and mineralized tuff. These bands are parallel to the main body in strike and dip, but are not persistent themselves, coalescing and pinching out and in reality forming a sort of stockwork. The bands are generally high in lead and low in zinc. A slight percentage of copper is generally found on their edges. From both sides of these bands the mineralization extends far out into the tuff, gradually merging into barren rock. Occasional seams and patches of ore are found at considerable distances. There is no sharp boundary between mineralized and unmineralized country rock as a general thing, although this condi-

[1] M. H. Loveman, "Geology of the Bawdwin Mines, Burma, Asia," *Trans. Amer. Inst. Min. Eng.*, Bull. 120, 1916, pp. 2119-2143.

[2] J. Coggin Brown, Geology and Ore Deposits of the Bawdwin Mines, *Rec. Geol. Surv. Ind.*, XLVIII (1917), pp. 121-178.

tion is approximated in a few places by fault planes. Pyrite is found to a limited extent in the main ore-body, but attains a much greater abundance along the edges where it is disseminated all through the rock as a multitude of very small (microscopic) cubes. The central core of solid ore in the Chinaman lode attains at points a thickness of more than 80 feet, and on some horizons maintains an average width of 55 feet for over 800 feet in length, and, as stated above, an average of 50 feet for 200 feet additional. In this core the gangue is generally very finely disseminated quartz grains. The extreme richness in metal content of the ore-body is best shown by the fact that a block roughly 800 feet long by 600 feet deep by 30 feet wide contains about 1,750,000 long tons with an average value of approximately Ag 30 ozs., Pb 31 per cent., and Zn 29 per cent. A weathered block of the same size of solid galena and sphalerite with equal amounts of Pb and Zn would contain approximately 2,300,000 long tons. Thus the block of the mine is over 75 per cent. solid lead and zinc sulphides. A gradual thinning of the ore-body takes place on approaching the underlying sediments."[1]

The upper portion of the ore-body has been largely worked out by the ancient Chinese, and it is rare to find sulphides on the surface. The gossan consists of a wide zone of soft rock stained with oxides of iron and carbonates and sulphates of copper and lead. For considerable distances it carries from 3 to 4 ozs. of silver and about 5 per cent. of lead. It is quarried for use as a siliceous flux in smelting operations. A characteristic assay follows: Ag, 3 ozs.; Pb, 5·8 per cent.; Zn, 0·7 per cent.; SiO_2, 58·6 per cent., Fe, 17·7 per cent. The depth of the gossan is extremely variable, but very rarely is more than 50 feet. At approximately this depth it is succeeded by a zone of secondary copper sulphides, principally chalcocite with some bornite. The chalcocite occurs largely as a replacement of sphalerite. The secondary copper-ores cannot be considered as occurring in a well-marked zone over the whole ore-body, but simply at a few favourable places, at some points stretching well up into the oxidised ores and at others well down into the normal sulphides. The secondary copper is not present in large enough amounts to be commercially important. The points at which the chalcocite occurs are

[1] Loveman, *loc. cit.*, pp. 2132-2133.

about 100 feet above the present water level, but, as erosion has been rapid, it probably marks the water-table level at a not very distant period. The zinc and lead sulphides, which, as remarked previously, at some points crop out on the surface, extend down to the greatest depth yet reached, about 725 feet, with practically no change in their character or relationship to each other. The normal zinc-lead ore of the mine is an extremely intimate mixture of sphalerite and galena; the sphalerite, which is the older, has a very fine granular structure, the grains varying from about 0·015 to 0·16 m.m. in diameter. The galena forms around the separate grains of sphalerite, and as thin filaments running through the zinc. The ore grades off in both directions from this fine mixture, towards the zinc end to solid masses of soft, earthy sphalerite with occasional stretches of hard, dark sphalerite probably rather high in its iron content, and towards the lead end to masses of pure, coarsely cubical galena. The silver content rises and falls consistently with the lead and independently of the zinc, indicating that the silver is largely contained in the lead. The presence of copper even in small amounts destroys the silver lead ratio, as the copper present in the small veins adjoining the main ore-body carries a high silver content. As a general statement it can be said that 1 per cent. of lead carries 1 oz. of silver. Silver minerals have not been detected in any form, but, as stated above, it seems most probable that the silver is present as argentite intimately associated with the galena.

The following assays show the relations between the silver and the lead, and also represent typical assays[1] of high-lead, high-zinc, zinc-lead and lower grade ores.

——	Ag. (ounces).	Pb. (per cent.)	Zn. (per cent.)
Silver-lead ore	47·6 54·4	50·4 50·0	19·2 24·1
High-zinc ore	11·0 15·5	11·2 13·6	38·8 40·7
Zinc-lead ore	38·5	33·9	36·3
Second grade ore	11·8 18·0	22·5 20·0	7·0 12·5

[1] M. H. Loveman, *loc. cit.*, pp. 2134-2135.

The ore deposits occur in a broad zone of faulting in which several complicated movements have taken place. The southern end of the Chinaman ore-body is cut off by a dominant fault, and its extension has still to be located.

Regarding the origin of the ores, M. H. Loveman has written (*ibid.*, p. 2140) :—" The ore-bodies at Bawdwin have been formed by the metasomatic replacement of the rhyolite tuff by sulphides deposited from hot solutions, which rose from below along an intensely crushed and sheared zone....... Whatever evidence there is, however, appears to indicate that the rhyolite is not responsible for the metal-bearing solutions."

J. Coggin Brown, working independently, concluded as a working hypothesis " that the ore-bodies at Bawdwin were formed by hot solutions from an underlying granitic magma, rising along shattered fault planes previously produced, and replacing congenial rocks, such as rhyolite tuffs whenever they happened to lie in their lines of circulation.

The ancient Chinese slags of Bawdwin are now almost exhausted, but the loss of lead from this source is more than compensated for by the additional supplies available from the mine itself.

Southern Shan States.

446 tons of lead-ore were produced in the period under review from the Southern Shan States, the annual output rising from 12 tons in 1914 to 143 in 1916, 146 in 1917 and 117 tons in 1918. The deposits are situated in two small States of the Myelat division, but they have not been examined in recent years.

Putao.

Vast quantities of lead slag were said to be found in the newly constituted district of Putao in Northern Burma and steps were recently taken to have them examined. But the reports proved to be wild exaggerations, the amount of slag being quite insignificant. Small veinlets of galena were observed in a group of calcareous rocks (siliceous limestone and schist) in the Nam Tamai and Nam Tisang valleys ; but they were found to be of no economic value.[2]

Indian localities.

Small productions of lead-ore were reported from Drug in the Central Provinces, from Chitaldrug in Mysore, and from Kashmir, the outputs for the quinquennium being 20, 7 and 1·9 tons respectively.

[1] *Rec., Geol. Surv. Ind.*, XLVIII, 175 (1917).
[2] **M. Stuart: The Galena Deposits of North-Eastern Putao.** *Rec., Geol. Surv. Ind.*, **L, 241 (1919).**

Silver is obtained as a by-product in the extraction of gold* at the Jibutil Gold mines of Anantapur. Production has been as follows :—

Madras : silver from Anantapur.

	Ounces.
1915	512
1916	1,362
1917	1,281
1918	1,169
	4,324

The localities already mentioned include all those from which ores of lead or silver were won during the period under review. In the last quinquennial review for the years 1909-13, it has been pointed out that galena is widely distributed in both India and Burma, and that unsuccessful attempts have been made from time to time to mine it in the Manbhum district of Bihar and Orissa, at Mount Pima in the Yamethin district of Burma, and at Sleemanabad in the Central Provinces. In the period 1914-18, no investigations have been carried out by the Geological Survey into the occurrence or distribution of lead ores except at Bawdwin, and the only new fact worthy of mention here is that lead sulphide is now known to be of wider distribution in Burma than was formerly the case, though up to the time of writing nothing new of commercial importance has been discovered. It occurs as a scanty though prevalent associate with the tin and tungsten ores of Tenasserim, in veins of the Siamese frontier granite, in granite of the Yamethin and Toungoo districts and in the Plateau Limestone of the Southern Shan States.

Future of the lead and silver industries.

By the year 1916 India had become self-supporting as regards lead, and the annual production of the Bawdwin mines is now sufficient to satisfy the demands of India and Ceylon, which are said to be about 15,000 to 16,000 tons yearly, chiefly for the manufacture of tea-lead, but also for ordnance purposes and for sheets, pipes and solder.[1] According to the same authority, the Burmese pig lead, though of high grade, is not pure enough for making sheets for some chemical purposes, such as sulphuric acid manufacture; but it has been found possible to produce lead of the requisite

[1] L. L. Fermor. Indian Munitions Board Industrial Handbook, p. 57

degree of purity by further treatment, and it is proposed to use it in connection with the scheme to smelt the Burmese zinc concentrates at Sakchi and recover the sulphur as acid.

The large ore reserves of the Bawdwin mines alone guarantee the future production of lead and silver in India for many years to come. As regards silver:—"The proposals for the extension of smelting facilities at Nam Tu will give a daily production of 21,000 ounces of silver or some 7,000,000 ounces of silver yearly. At the present time, this silver, which is of a high degree of purity, is used in the coinage of rupees, though it forms but a small proportion of the total amount of metal used for that purpose." [1]

Magnesite.

[H. H. HAYDEN.]

Salem district.

The Chalk Hills lying between the town of Salem and the Shevaroy Hills in Southern India derive their name from the general effect of the network of white magnesite veins, which are prominent over an area of about 4½ square miles. The occurrence was well known early in the last century, when Mr. J. M. Heath, then 'Commercial' Resident (Collector) at Salem on behalf of the East India Company, was such an energetic prospector. The area was described by W. King and R. B. Foote in 1864,[2] and the origin of the magnesite by alteration of dunite (olivine-rock), was first noticed in 1892.[3]

A more complete account of the area with map and photographs was published in 1896 by C. S. Middlemiss,[4] who drew special attention to the large quantities of mineral easily obtainable.

Attention was again directed to the place by Mr. H. G. Turner, and through his enterprise the Magnesite Syndicate, Ltd., was formed to develope the mineral. A paper by Mr. H. H. Dains [5] demonstrates the high quality of the material obtainable, the magnesite containing 96-97 per cent. of magnesium carbonate in

[1] L. L. Fermor. *Op. cit.*, 2nd edition, p. 142.
[2] *Mem. Geol. Surv. Ind.*, IV, pp. 312—317.
[3] T. H Holland, *Rec. Geol. Surv. Ind.*, XXV, p. 144, footnote.
[4] *Rec. Geol. Surv. Ind.*, XXIX, p. 31.
[5] 'The Indian Magnesite Industry.' *Journ. Soc. Chem. Industry*, XXVIII, p. 503 (1909).

ordinary, and 99 per cent. in picked, samples. The following analyses have been made on fair samples :—

TABLE 56.—*Analyses of Salem Magnesite.*

—	Blount.	Dains.	Pattison (cargo sample).	Ferguson. 1.	Ferguson. 2.
Silica	0·22	0·29	1·17	0·31	1·70
Iron oxide	0·30	0·65	0·14	0·40	0·65
Alumina				0·10	0·10
Manganese oxide	...	0·20	0·06	...	...
Lime	*Nil.*	0·83	0·78	...	...
Magnesium oxide	47·35	46·42	46·28	97·80	97·4
Carbon dioxide	51·44	50·71	50·10		
Water	0·27	0·16	1·30	0·60	Traces.
Sulphuric acid	...	...	0·03	...	...
Phosphoric acid	...	...	0·01	...	...
TOTAL	99·58	99·26	99·87	100·06(*a*)	99·85
Magnesium carbonate	*98·79*	*97·13*	*96·34*	*97·80*	*97·40*

(*a*) Including 0·85 calcium carbonate.

The magnesite is calcined on the spot to produce (*a*) lightly calcined or caustic magnesia, obtained at a temperature of about 800°C., and (*b*) dead-burnt, sintered, or shrunk magnesia, obtained by calcination at about 1,700°C. The following analyses, given by Mr. Dains, represent the two products as obtained in gas-fired kilns :—

TABLE 57.—*Analyses of calcined Salem magnesite.*

—	Caustic magnesia.		Dead-burnt magnesia.
Loss on ignition	1·82	2·31	0·34
Silica	...	...	4·38
Insoluble residue	1·13	0·54	...
Ferric oxide and alumina	0·63	0·44	1·12
Lime	1·06	1·03	1·04
Magnesia	95·80	96·10	93·12
TOTAL	100·44	100·42	100·00

Experiments made on a considerable scale on behalf of Mr. H. G. Turner[1] showed that when highly heated in an electric furnace the Salem magnesite yields a hard dense crystalline mass of the greatest refractory quality.

Uses of magnesite.

Magnesite has many applications, of which its use as a source of carbon dioxide and as a refractory material are amongst the most important.[1] Before the war practically the whole of the lightly calcined magnesia of Salem was shipped to Europe for use as Sorel Cement for the manufacture of artificial stone, floorings, etc. This cement is formed by mixing caustic magnesia with a solution of magnesium chloride and will carry up to 20 parts of sand for one of magnesia. During the war, however, European supplies of magnesite were not always available and in the years 1916 and 1917 large quantities were shipped to the United Kingdom from Salem. The effects of this can be seen in the attached table showing the Indian production during the period under review.

TABLE 58.—*Production of Magnesite during the years 1914 to 1918.*

—	MADRAS. (CHALK HILLS).		MYSORE.		TOTAL.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£
1914	399	*130*	1,281	(*a*)*427*	1,680	*557*
1915	7,450	*3,973*	...	...	7,450	*3,973*
1916	17,540	*14,032*	100	(*a*)*80*	17,640	*14,112*
1917	18,192	*14,554*	10	*5*	18,202	*14,559*
1918	5,773	*4,618*	80	*23*	5,853	*4,641*
Average	*9,871*	*7,461*	*294*	*107*	*10,165*	*7,568*

(*a*) Estimated.

[1] *Rec. Geol. Surv. Ind.*, XXXIX, 126.

Magnesite is known to occur at several other places in Southern India, always as veins traversing peridotites, for example at Seringala in Coorg, on the Cauvery above Fraserpet, in other parts of the Salem district,[1] in the Trichinopoly district, and in the Hassan and Mysore districts of Mysore.[2] In 1913, the Tata Iron and Steel Company acquired magnesite properties in the Mysore district with a view to producing refractory materials for their furnaces at Sakchi. The output in 1913 was 2,112 tons, and in 1914, 1,281. Since then, the output has been insignificant, amounting to 100 tons in 1916, 10 tons in 1917, and 80 tons in 1918. According to Mr. A. Ghose large quantities of magnesite, although of inferior quality, occur in association with the steatite deposits of Muddavaram and Musila Cheruvu in the Karnul district (see page 320).

Other occurrences.

Manganese.

[L. L. FERMOR.]

The previous Review referred to the rapid development of the manganese-quarrying industry in India during the early years of the present century, the zenith being reached in 1907 with an output of 902,291 tons of ore. After this year the industry maintained a position of comparative stability with an average annual production of 712,797 tons for the years 1909 to 1913. In 1908 India took the lead amongst the world's producers of manganese-ore, hitherto held by Russia, who, however, resumed this lead in 1912 and 1913. The present quinquennial period 1914—1918 has coincided approximately with the period of the war, marked by controlled and restricted exports, the control being due to the necessity of ensuring that a mineral of such importance to the iron and steel industry should not reach enemy countries, either directly as ore or in the form of alloys, iron, or steel, whilst the restrictions were due to the well-known shortage of shipping. In spite of these adverse factors the Indian production during the quinquennium averaged 577,457 tons annually;

Progress of the industry.

[1] W. King and R. B. Foote, *Mem. Geol. Surv. Ind.*, IV, pp. 318—324.

[2] A. Primrose, *Rec. Mysore Geol. Dept.*, III, p. 239; IV, p. 178. V. S. Sambasiva Iyer, *op. cit.*, IV, p. 61. Annual Reports of the Chief Inspector of Mines in Mysore.

this, in the circumstances, must be considered satisfactory, although the exports for the official years 1914-15 to 1918-19 averaged only 491,558 tons with a resultant accumulation in India during the period of over 300,000 tons of stocks, after allowing for ore railed to Sakchi and Kulti for use in the Indian iron and steel industry. This excess of production over exports occurred partly during 1914, with its accompanying disorganisation of business due to the incidence of war, and partly during the last two years, 1917 and 1918, with their acute shortage of shipping: 1915 and 1916 were in fact the only years of the period in which production and exports approximately balanced.

Russia retained her position as leading producer up to 1914: but subsequently the circumstances of war, especially the closing of the Dardanelles, which isolated Russia from friendly consumers, led to the reduction of the industry to the small dimensions necessary to satisfy the home demands of the Russian iron and steel industry. Subsequent internal troubles have caused the practical stoppage of the industry, and on account of a system of permits giving priority of shipment to foodstuffs and other essential requirements, even the opening of the Dardanelles has not led to the shipment of the stocks accumulated at Poti.[1] With the present arrangement of boundaries the ore-fields of the Caucasus are included within the new republic of Georgia, and the fields of Nikopol within the Ukraine.

The disappearance of Russia from allied markets was not, however, of very serious moment to the Allies, as it coincided with the isolation of one of the chief consumers of the world's supplies of manganese-ore, namely Germany, who before the war imported large quantities from both India and Russia. Such shortage as resulted was felt chiefly in the United States, owing partly to the difficulty of arranging shipping from India, and led to a great development in the manganese industry of Brazil, who, as will be seen from fig. 12, rose from third to second place amongst the world's producers, concurrently with India's resumption of first place. The exports of Brazil were taken almost entirely by the United States, not only to replace former imports from Russia and India, but also to balance a great reduction in the imports of ferro-manganese.

[1] *The Mineral Industry* for 1918, p. 475.

On account, however, of the great increase in the American iron and steel industry for the provision of munitions of war, supplies of manganese-ore were still inadequate, with the result that all known occurrences of manganese-ore in the United States of America were investigated, of whatever grade, so that the output of manganese-ores containing 40 per cent. manganese or over rose from 2,677 metric tons in 1914 to 124,244 metric tons in 1917, and of ores containing over 35 per cent. manganese to 309,254 metric tons in 1918. At the same time the output in the United States of America of ores carrying less than the above percentages of manganese rose from 201,650 metric tons in 1914 to 1,527,705 metric tons in 1918. To allow for the use of these lower grade ores not only was the composition of standard ferro-managanese in the States reduced from 80 per cent to 70 per cent. manganese, but many American smelters had to adapt their practice to the use of spiegeleisen in place of ferro-manganese. The great increase in the American manganese industry just referred to is not, however, thought to be permanent, as it took place under the stimulus of restricted supplies and high prices. With the fall in the price of manganese that must result as soon as there is any serious decrease in ocean freights concurrently with more settled conditions in the South Russian States, the American manganese industry will probably revert towards its former position. In all probability the same factors will not result in a parallel setback to the Brazilian manganese industry; but as this alone will be insufficient to supply the entire future needs of America, there is every likelihood that India may in the not too distant future resume her position as an exporter of manganese-ore to the United States.

Although the Indian manganese industry has reached a position of comparative stability, it is of course subject to variations in prosperity, as is illustrated graphically by the fluctuations in production recorded in fig. 5, page 21. On comparing this diagram with the curves of the world's production of pig iron and steel shown in fig. 11 it is seen that the variations in the activity of the Indian manganese industry are to be correlated with variations in the activity of the iron and steel industry. In the previous Review it was pointed out that the maxima of manganese-ore production coincide with maxima of steel production, whilst the minima lag one year behind. This lag means, of course, overproduction during years of lessened

demand, with resultant accumulation of stocks. The varying demands of the steel trade make their effect felt on the manganese industry in part through corresponding variations in the price of manganese-ore, and it is interesting therefore to compare the curves of the world's production of iron and steel forming the lower part of fig. 11 with the curves showing the price of manganese-ore forming the upper part of the same figure. The two sets of curves have of recent years moved in close sympathy, but the very sharp rise in the curve of prices since 1914 indicates the introduction of another factor into the problem besides the activity of the steel trade. This factor is, of course, the excessively high freights prevailing during the war on account of the shortage of shipping. The consequence is that the rapid rise in the curve of market price of manganese-ore cannot be taken as the measure of a corresponding increase in the profits accruing to the manganese industry of India. (See table 60, page 152.)

As features representing definite progress in the industry in India during the quinquennium, mention may be made here of the manufacture of ferro-manganese in India by both the Tata Iron and Steel Co. and the Bengal Iron and Steel Co. (see page 178) and of the commencement of underground work at at least two localities (see page 182).

Prices.

Quotations of the prices paid per unit for manganese-ore delivered at United Kingdom ports during the quinquennium have been scanty, and in place of the tabular statement showing the half-yearly prices of three grades of ore given in previous Reviews the following table No. 59 is all that can be offered. It is based on figures given, some in the *Mining Journal*, and some in the *Mining Magazine*. The mean prices shown in the third column have been obtained by averaging the prices at the beginning, middle, and end of each year. In fig. 11 these prices are compared with the world's production of pig-iron and steel.[1]

[1] Strictly speaking the portion of the above curves representing the war period should give the world's production exclusive of those countries—Austria-Hungary, Belgium, Germany, and Russia—that were isolated from the world's markets. Such reduced figures give curves very similar to those actually shown, but faulted for the period 1914 to 1918 to a position about 20 million tons lower in the diagram.

TABLE 59.—*Variation in the Price of First-grade Manganese-ore c.i.f. at United Kingdom Ports.*

Date.	Price per unit in pence.	Mean price for year in pence.
January 1914	10—10¼	10·17
July 1914	9¼—9½	
December 1914	11	20·17
July 1915	19—20	
January 1916	30	30·7
July 1916	30	
December 1916	32	37·7
July 1917	38—39	
January 1918	42—43	42·5
July 1918	42—43	
January 1919	42—43	35·2
July 1919	27	
January 1920	36	—

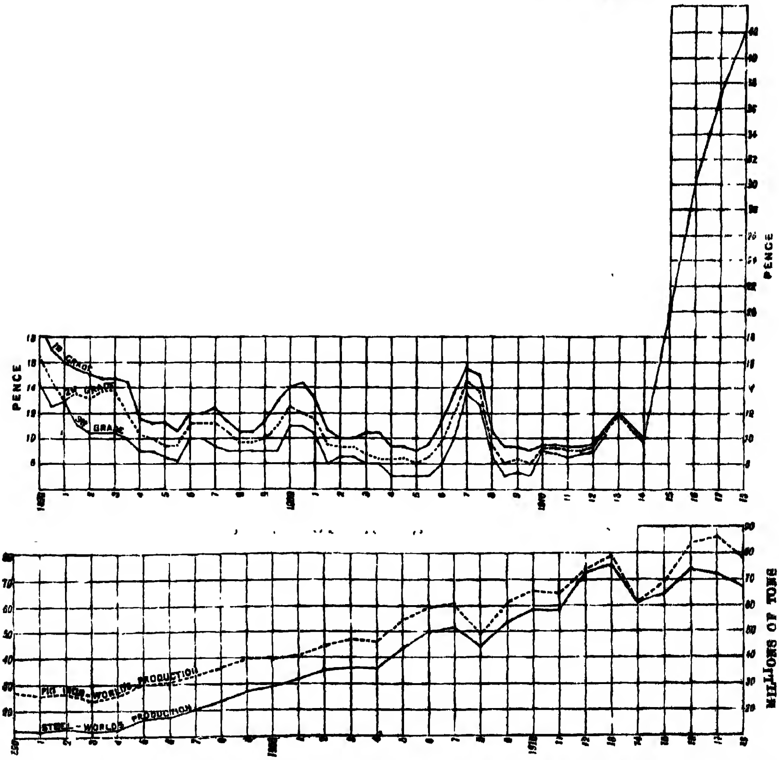


FIG. 11.—*Variation in the Prices of Manganese-ore at United Kingdom Ports since 1890, compared with the World's Production of Pig-iron and Steel.*

As already noticed the steep rise in the curve of prices is largely due to enhanced freights : consequently, in order to discover the extent to which the Indian manganese industry may have benefited by the increased prices it is necessary to eliminate the portions representing freight and reduce to f.o.b. prices. This is desirable also, because, for the same reason, it has been found necessary during the war to base the sliding scale of royalties applied in the Central Provinces and Bombay on f.o.b. prices instead of the c.i.f. prices formerly used. The following table gives the necessary data and reveals that although the price of manganese-ore during the war c.i.f. at United Kingdom ports increased by some 100 to 320 per cent., the effective increase to the manganese industry of India was only some 60 to 100 per cent.

TABLE 60.—*Comparison of Ocean Freights with c.i.f. and f.o.b. Prices of Indian Manganese-ore.*

—	Average freights per ton from Calcutta to U. K. ports.[1]	Average price of 1st grade ore per unit c.i.f. U. K. ports.	Value per ton 50 % ore c.i.f. U. K. ports.	Value per ton f.o.b. Indian ports.[2]	Corresponding price per unit f.o.b. Indian ports.
	£. s. d.	*Pence.*	£. s. d.	£. s. d.	*Pence.*
1909 . .	11 7½	9·25	1 18 6½	1 5 3	6·06
1910 . .	12 6	9·46	1 19 5	1 5 3	6·06
1911 . .	12 6	9·46	1 19 5	1 5 3	6·06
1912 . .	16 5½	10·91	2 5 5½	1 7 4	6·56
1913 . .	19 5½	11·12	2 6 4	1 5 7½	6·15
1914 . .	17 9	10·17	2 2 4½	1 3 11½	5·75
1915 . .	2 1 6	20·17	4 4 0½	2 0 0½	9·6
1916 . .	4 1 8	30·7	6 7 11	2 3 9	10·5
1917 . .	5 11 8	37·7	7 17 1	2 2 11	10·3
1918 . .	6 3 0½	42·5	8 17 1	2 11 6½	12·37

Companies working. During the period now under review the following limited companies were at work. Most of them were formed during the years 1905 to 1907 ; but the Vizianagram Mining Co. was floated in 1895 :—

Bombay—

1. The Shivrajpur Syndicate.
2. The Bamankua Manganese Company.

[1] Figures for Bombay are very similar as far as available.
[2] Obtained by deducting from c.i.f. value not only ocean freights but also destination charges, taken at 1*s*. 8*d*. up to and including 1914, and thereafter at 2*s*. 6*d*.

Central Provinces—

1. The Central India Mining Company.
2. The Indian Manganese Company.
3. The Central Provinces Prospecting Syndicate.
4. The Netra Manganese Company.

Madras—

1. The Vizianagram Mining Company.
2. The General Sandur Mining Company.

Mysore—

1. The Workington Iron and Steel Company.
2. The Peninsular Minerals Company of Mysore.

Other prominent workers during this quinquennium have been :—

The Carnegie Steel Company: Central Provinces.
The Tata Iron and Steel Company: Central Provinces.
Byramjee, Pestonjee & Company: Central Provinces.
D. Laxminarayan: Central Provinces.
Lalbehari Ramcharan: Central Provinces.
Nagpur Manganese Mining Syndicate: Central Provinces.
Seth Gowardhandas: Central Provinces.
Rai Bahadur Bansilal Abirchand Mining Syndicate: Central Provinces and Bihar and Orissa.
Madhulal Doogar: Bihar and Orissa.
The New Gangpur Mining Co.: Bihar and Orissa.

Production.

Table 61 shows the production from each district, state, and province during the past five years, and fig. 5 on page 21 shows the progress of the industry since its beginning. From this it will be seen that the Central Provinces is by far the most important province as a producer of manganese. The figures in this table represent, except in a few cases, quantities of ore won or raised, and not of ore railed.

Comparing this quinquennium with the previous five years it will be seen that the average annual production of manganese-ore for the whole of India shows a considerable decrease from 712,797 tons to 577,457 tons. As has already been remarked, this is not unsatisfactory in view of the control over and restriction on exports in existence during the war period. When, however, the comparison is made province by province, it is seen that this marked decrease is not general. The Central Provinces actually show a small increase in output of some 7,000 tons as compared with the previous quinquennium whilst the decrease in the case of Bombay is trivial and in the case

TABLE 61.—*Production of Manganese-ore in*

YEAR.	BIHAR AND ORISSA.			BOMBAY.				CENTRAL INDIA.	CENTRAL		
	Singhbhum.	Gangpur.	Total.	Belgaum.	Chota Udepur.	Panch Mahals.	Total.	Jhabua.	Balaghat.	Bhandara.	Chhindwara.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons	Tons.
1914 .	..	6,070	6,070	..	7,735	19,488	27,223	6,642	221,159	82,055	87,114
1915 .	507	..	507	..	..	26,915	26,915	366	180,609	78,627	46,941
1916 .	2	2,832	2,834	1,765	7,951	46,160	55,876	..	264,032	86,344	53,977
1917 .	126	11,780	11,906	..	417	26,690	27,107	..	260,706	44,997	66,235
1918 .	450	15,895	16,345	..	7,202	30,893	38,095	..	214,972	32,245	72,398
TOTAL .	1,085	36,577	37,662	1,765	23,305	150,146	175,216	7,008	1,141,478	324,268	326,665
Provincial average.	..	..	*7,532*	..	..	..	*35,043*	*1,402*	..	..	..
Provincial average 1909-13.	..	..	32,112	..	..	..	35,672	8,555	..	..	..

India for the five years 1914 to 1918.

Provinces.			Madras.			Mysore				Totals for whole of India.	*Totals for whole of India.*
Jubbulpore.	Nagpur.	**Total.**	Sandur.	Vizagapatam.	**Total.**	Chitaldrug.	Shimoga.	Tumkur.	**Total.**		
Tons.	Tons.	**Tons.**	Tons.	Tons.	**Tons.**	Tons.	Tons.	Tons.	**Tons.**	**Statute Tons.**	*Metric Tons.*
..	174,562	**564,890**	33,643	26,375	**60,018**	..	18,055	..	**18,055**	**682,898**	*693,824*
11	93,027	**399,215**	..	288	**288**	..	23,125	..	**23,125**	**450,416**	*457,623*
576	153,899	**558,828**	..	2,755	**2,755**	700	23,242	969	**24,911**	**645,204**	*655,527*
300	145,0[illegible]	**517,841**	..	1,682	**1,682**	2,843	26,581	2,853	**32,277**	**590,818**	*600,266*
65	118,948	**438,628**	..	2,230	**2,230**	313	20,529	1,813	**22,655**	**517,953**	*526,240*
952	686,030	**2,479,402**	33,643	33,330	**66,973**	3,856	111,532	5,635	**121,023**	**2,887,284**	2,933,480
..	..	*495,880*	..	..	*13,395*	..	..	..	*24,205*	*577,457*	*586,696*
..	..	488 485	..	..	119,694	..	..	..	28,280	712,797	724,201

of Mysore only some 4,000 tons. The decrease is, in fact, largely due to a great falling off in the average annual output of the Madras Presidency from 119,694 tons in the previous quinquennium to 13,395 tons during the present period, representing the complete cessation of work in Sandur since early in the war and the fall of the output of Vizagapatam to insignificant dimensions on account of cessation of work for about a year after the outbreak of war resulting in the flooding of the two principal mines. In the case of Sandur this stoppage is said to be due to high ocean freights, but is no doubt also connected with the fact that the ore from this State was largely exported to Belgium and Germany before the war. The fall in the average annual output of Bihar and Orissa from 32,112 tons to 7,532 tons is partly due to the death of Babu Madhu Lal Doogar, the former owner of the mine which lead to a cessation of work. The decrease in Central India is due to the closure of work at Kajlidongri since 1916, where only a small quantity of ore is supposed to be still left in the ground.

Production of foreign countries.

The growth of the Indian manganese industry during the past five years, and its importance as compared with that of other countries, can be seen from table 62, giving the world's production of manganese-ore for the five years 1913 to 1917, and for 1918 as far as available. The figures have been taken chiefly from "*The Mineral Industry.*"

From this table it will be seen that for some years the three leading countries producing manganese-ore have been Brazil, India, and Russia. In the previous quinquennium the output, or rather exports, of Brazil sank from a maximum of 253,953 metric tons in 1910 to 122,300 metric tons in 1913, the average annual exports being 189,160 metric tons. During the same period the production of India fluctuated between about 650,000 and 830,000 tons, averaging 724,201 metric tons, whilst that of Russia rose almost continuously from 574,938 metric tons in 1909 to 1,171,000 metric tons in 1913, with an annual average of 752,797 metric tons. As already recorded (page 148), and as is shown graphically in fig. 12, during the present quinquennium the war has lead ultimately to an almost complete cessation of the Russian manganese industry, and to a moderate contraction of that of India, with the resultant great expansion in the production of manganese-ore in Brazil and the United State of America, so that in 1918 the first three places amongst the

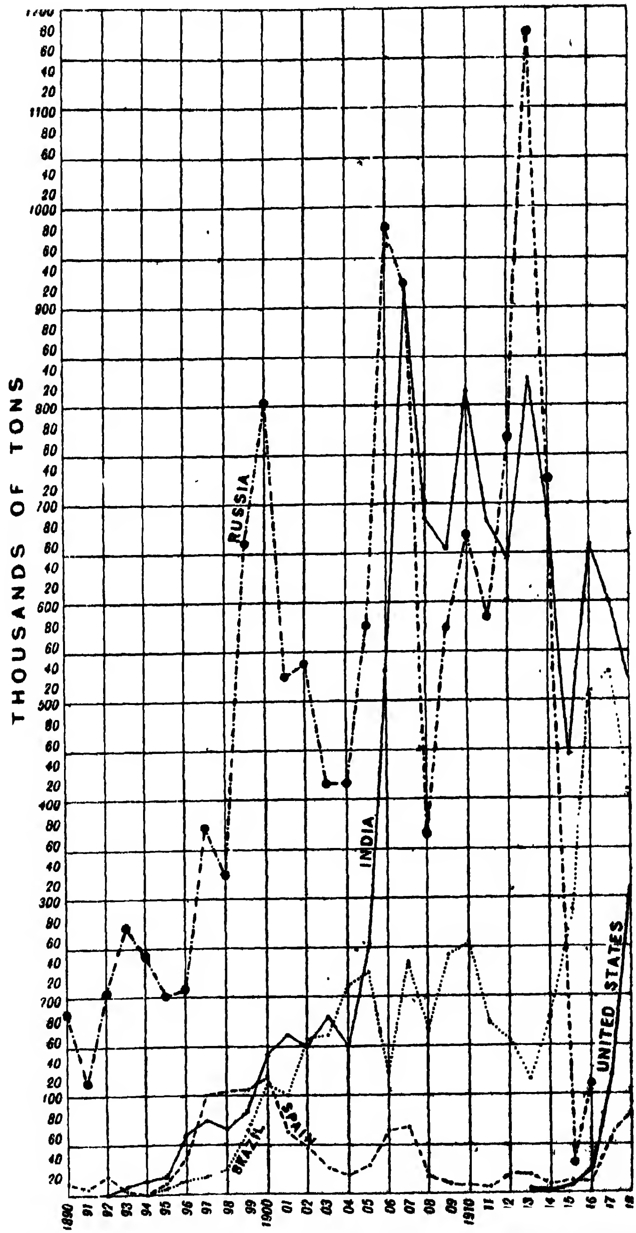


Fig. 12.—*Production of manganese-ore in the five leading countries since 1890.*

TABLE 62.—*World's Annual Production of Manganese-ore during the years 1913 to 1918.*

(Metric Tons.)

YEAR.	Austria-Hungary. (*a*)	Brazil. (*d*)	Cuba.	Egypt.	France.	Greece.	India.	Italy.	Japan.	Russia.	Spain.	Sweden.	United Kingdom	United States.	Other Countries.	World's Total.
1913 .	40,249	122,300	(*c*)	..	7,732	556	828,088	1,622	2,313	1,171,000	21,594	4,001	5,480	4,113	27	**2,209,075**
1914 .	15,533(*b*)	183,630	(*c*)	..	(*c*)	558	693,824	1,649	17,076	737,300	8,965	3,643	3,496	2,677	31	**(*f*)1,700,000**
1915 .	(*c*)	288,671	9,145	..	(*c*)	408	457,623	12,577	25,870	(*f*)84,980	14,328	7,607	4,716	9,865	885	**(*f*)1,000,000**
1916 .	(*c*)	503,130	33,653	..	(*c*)	3,600	655,527	18,147	7,874	(*f*)120,000	14,178	8,894	5,223	27,431	5,391	**(*f*)1,500,000**
1917 .	(*c*)	532,855	45,223(*d*)	..	(*c*)	*Nil*	600,266	24,532	51,366	(*c*)	57,474	19,873	10,104	124,244	2,389	**(*f*)1,600,000**
1918 .	(*c*)	393,388	(*d*) 183,305	27,498	(*c*)	(*c*)	526,240	31,896	(*c*)	(*e*)	77,714	16,570	17,737	309,254	7,423	**(*f*)1,650,000**

(*a*) Includes Bosnia and Herzegovina.
(*b*) Excludes Austria.
(*c*) Figures not available.
(*d*) Exports.
(*e*) Railings from Caucasus, mostly stocked at Poti.
(*f*) Estimated after estimated additions for countries of which statistics are incomplete or not available.

world's producers were held by India, Brazil, and the United States of America, in the order named. Expressed in terms of annual average figures in metric tons during the quinquennium under review the output of India has sunk to 586,696 tons, that of Brazil has risen to 380,335 tons, whilst the output of the United States of America has risen from 2,442 tons during the previous quinquennium to 94,694 tons during the present.

A few new producers have also appeared on the scene. Egypt is credited with an output of 27,498 metric tons in 1918, whilst a large body of ore has been discovered in West Africa (Gold Coast): further the production of Cuba has increased suddenly to an estimated figure of about 100,000 tons in 1918.

Production of manganiferous iron-ores.

In table 63 are given such figures as are available of the world's output of manganiferous iron-ores. According to the practice by which all ores containing less than 40 per cent. manganese are classified as manganiferous iron-ores rather than as manganese-ores, a certain very small proportion of the Indian production should be classified under this heading. Of the ores mined in the United States a large proportion is very low in manganese (1 to 8 per cent.), but all ores under 40 per cent. are included, except in 1918 when the line was drawn at 35 per cent. The importance of large stores of manganiferous iron-ores to a country poor in manganese-ores proper is shown by the case of the United States where an insufficiency of imports of manganese-ore during the war was mitigated by a large expansion

TABLE 63.—*World's Production of Manganiferous Iron-ores from 1913 to 1918.*

(Metric Tons.)

Year.	Germany. (a)	Greece.	Italy.	United States.
1913	330,797	6,323	*Nil*	693,901
1914	(b)	1,315	*Nil*	201,650
1915	(b)	1,041	*Nil*	361,675
1916	(b)	818	4,360	557,619
1917	(b)	509	4,806	1,121,229
1918	(b)	(b)	805	1,527,705

(a) Includes a certain amount of true manganese-ore.
(b) Figures not available.

in the output of indigenous manganiferous iron-ores accompanied by modifications in furnace practice where necessary. In the case of Germany, also, it seems probable that the cessation of imports of manganese-ore from Russia and India was met to a large extent by a greatly increased production of the manganiferous iron-ores of Siegerland,[1] and it is unfortunate therefore that the relevant figures are not available in time to be included in the above table.

Exports.

For comparison with the annual figures of production of manganese-ore in India, the export figures during the years 1914-15 to 1918-19 are given in table 64 stated separately for each port.

TABLE 64.—*Exports of Indian Manganese-ore from April 1st, 1914, to March 31st, 1919.*

(Statute Tons.)

YEAR.	Vizagapatam.	Bombay.	Calcutta.	Mormugao.	Yearly Total.
1914-15	14,250	365,286	61,054	66,392	**506,982**
1915-16	2,000	392,915	77,648	1,330	**473,893**
1916-17	9,450	394,146	233,337	15,266	**652,199**
1917-18	7,400	247,608	176,822	5,825	**437,655**
1918-19	50	180,376	204,935	1,700	**387,061**

From table 65, giving the total Indian production and exports for the years 1892 to 1918, it will be seen that by the end of 1918 there was an excess of production over exports of over 800,000 tons, of which about 100,000 tons represent ore railed to Jamshedpur and Kulti for use in the Indian iron and steel industry during the present quinquennium (see page 181); the remainder represents stocks accumulated at the mines and ports.

[1] H. C. H. Carpenter, *Nature*, 4-11-15, p. 257.

TABLE 65.—*Comparison of Indian Manganese-ore Production with Exports.*

(Statute Tons.)

Period.	Ore produced.	Ore exported.	Excess of production over exports.
1892 to 1903	929,145	..	..
1892-93 to 1903-04	..	916,386	12,759
1904 to 1908	2,545,718	..	..
1904-05 to 1908-09	..	2,217,596	328,122
1909 to 1913	3,563,984	..	..
1909-10 to 1913-14	..	3,471,416	92,568
1914 to 1918	2,887,284	..	..
1914-15 to 1918-19	..	2,457,790	429,494
TOTAL	9,926,131	9,063,188	862,943

Distribution of Indian manganese-ore exports.

The distribution amongst foreign countries of the manganese-ores exported from India during the quinquennium is shown in table 68. When compared with the figures for the previous period this table shows certain abnormal features. The first is the disappearance of Belgium, Germany, Holland, and Austria-Hungary, from the importing countries for the period of the war: the imports to Holland recorded in the previous Review, were, it is interesting to note, intended for transmission to Germany, as also was the greater portion of the ore imported into Belgium. The second feature is the large decrease in the exports to France and the United States, and the third the large increase in the exports to the United Kingdom—1,680,796 tons in the present period as compared with 966,111 tons during the previous period.

Labour.

In Vizagapatam and Mysore an adequate supply of labour seems to be easily obtainable, but in the Central Provinces, Central India, the Sandur Hills, and other parts, labour has frequently to be imported. To relieve themselves of unnecessary trouble and responsibility the mine managers find it preferable to work through contractors, paying them at a given rate per 1,000 cubic feet of stacked and cleaned ore, and for dead-work at a given rate per 1,000 cubic feet of cavity made in the quarry in the case of soft 'deads,' or per 1,000 cubic

feet of waste measured in tubs or stacked in the case of hard 'deads.' The daily rates paid to the coolies by the contractors vary between the following limits in different parts of India :—

	Annas.
Men	3 to 10
Women	2 to 5
Children	1½ to 3

The average daily number of workers during the past five years is shown in table 66.

In order to permit of the comparison of the manganese with the coal industry as regards labour, the figures appertaining only to those mines that come under the Mines Act, 1901, are given in table 67. From these figures it is seen that the average number of persons employed daily on the manganese mines under the Act has been 13,242 for an average annual output of 482,857 tons, compared with 11,804 persons and an average annual output of 465,631 tons of ore for the previous quinquennial period. The number of tons of ore won annually per person employed has decreased steadily during the period from 42·5 tons in 1914 to only 30 tons in 1918, giving an average for the quinquennium of only 36·6 tons compared with 39·4 tons in the previous period. This decrease is due to the fact that most of the easily-won ore has been extracted so that more dead work is necessary every year. The output of coal per person employed was nearly three times the above figure (see table 31). The death-rate has been 0·18 per 1,000 persons employed as compared with 1·14 in the case of coal: these figures are lower than for the period 1909-13, when the corresponding figures were 0·63 and 1·38 respectively. At the same time the number of deaths per million tons won has decreased in the case of manganese from 15·9 in 1909-13 to 6 in 1914-18, and in the case of coal from 12·8 to 10·7.

TABLE 66.—*Daily number of Workers employed at the Manganese Quarries from 1914 to 1918.*

YEAR.	Bihar and Orissa.	Bombay.	Central India.	Central Provinces.	Madras.	Mysore.	TOTAL.
1914	671	866	291	13,169	2,673	604	**18,274**
1915	205	970	188	11,058	15	799	**13,235**
1916	417	1,927	(a)	16,683	293	1,083	**20,403**
1917	1,222	968	(a)	16,695	203	929	**20,017**
1918	1,585	1.334	(a)	16,446	317	436	**20,118**
Average	*822*	*1,213*	(b) *239*	*14,810*	*700*	*770*	*18,554*

(a) Mine closed. (b) Average for two years.

TABLE 67.—*Labour Statistics for Manganese Mines under the Mines Act, 1901.*

Year.	Average number of persons employed daily.	Production.	Output per person.	Number of deaths.
		Tons.	Tons.	
1914	13,061	555,672	42·5	..
1915	9,790	378,172	38·6	2
1916	15,538	568,032	36·5	9
1917	13,978	497,052	35·5	1
1918	13,843	415,357	30	..
TOTAL	**66,210**	**2,414,285**	..	..
Average	*13,242*	*482,857*	*36·6*	*2·4*

Cost of mining and transport.

The chief items in the cost of placing manganese-ore on the markets in Europe and America are the following :—

(1) Cost of mining (labour, tools, plant, establishment).
(2) Cost of transport to the railway.
(3) Cost of transport to the port of shipment.
(4) Cost of handling at the port of shipment.
(5) Cost of shipping to Europe or America.
(6) Destination charges.

Each of these six items—the first five of which vary according to the situation of the deposit—has been considered in detail in *Memoirs, Geol. Sur. Ind.*, XXXVII, Chapter XXIII to which the reader is referred. In the previous review an abstract was given showing the average cost of delivering *c.i.f.* at English and Continental ports ore derived from several of the producing areas. These figures were in the main based on information collected prior to 1910 and with the general rise in prices due to the war have ceased to be applicable. Revised figures for all the areas concerned have not been obtained, but it will be sufficient to give as an example the

TABLE 68.—*Distribution of exported Indian Manganese-ore for the years 1914-15 to 1918-19.(a)*

(Statute Tons.)

YEAR.	United Kingdom.	Belgium.	France.	Germany.	Italy.	United States.	Austria-Hungary.	Japan.	Egypt.	Other Countries.	Total recorded export for the year.
1914-15 . . .	227,281	66,043	46,326	14,250	..	73,503	4,030	9,157	..	..	440,590
1915-16 . . .	380,967	..	20,000	..	20,850	47,400	..	3,346	..	..	472,563
1916-17 . . .	463,850	..	61,940	..	28,400	65,062	..	17,480	200	1	636,933
1917-18 . . .	313,468	..	48,055	..	10,200	44,051	..	17,557	..	..	(b)433,331
1918-19 . . .	295,230	6,560	57,400	..	1,575	9,600	..	14,996	..	..	385,361
TOTAL .	1,680,796	72,603	233,721	14,250	61,025	239,616	4,030	62,536	200	1	2,368,778

(*a*) Excludes exports *viâ* Mormugao.
(*b*) Includes 1,501 tons of ferro-manganese

following revised figures for the Central Provinces, the most important producing province.

—	*Viâ* Bombay.			*Viâ* Calcutta.		
	Limits.		Average.	Limits.		Average.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Cost of mining (labour tools, plant and administration) .	2 0 0	9 0 0	5 0 0	..	..	5 0 0
Transport to rail-head . .	0 2 0	2 8 0	1 0 0	..	..	1 0 0
Railway freight . . .	8 4 8	10 6 8	9 0 0	9 8 4	11 9 5	10 0 0
Handling at port . . .	1 10 0	2 5 0	2 0 0	1 0 0	1 6 0	1 3 0
Agents' commission . . .	*Nil*	0 6 0	0 3 0	..	..	0 4 0
			17 3 0			17 7 0

These figures are applicable to the period 1914 to 1918, and on comparing them with the figures given in the memoir referred to above it will be seen that the average cost of delivering ore for the Central Provinces *f.o.b.* Bombay increased from about Rs. 14 per ton in the previous quinquennial period to a little over Rs. 17 during the period 1914 to 1918. Since 1918 railway freights have been increased by about Rs. 1-8-0 per ton to Bombay and 2 annas a ton to Calcutta. Taking an exchange value of 2 shillings to the rupee it will be seen that the cost of delivering manganese-ore *f.o.b.* Bombay has increased by about 100 per cent., expressed in sterling.

Royalties.

In British India the royalty leviable on the base metals is—

'$2\frac{1}{2}$ per cent. on the sale value at the pit's mouth, or on the surface, of the dressed ore or metal, convertible at the option of the Local Government to an equivalent charge per ton to be fixed annually for a term.'

Since it is inconvenient and very difficult to assess the royalties separately for each manganese-ore deposit and producer, it is customary in each area to assume average figures for the composition of the ore and for the costs of mining, transport, etc., and to apply them without distinction to all cases. Table 69 shows a sliding scale of royalties drawn up first for the Central Provinces by agreement between the local administration and the mining community. This scale has also been adopted for Bombay. In applying this table the average price for a period of a year should be used.

TABLE 69.—*Royalties, in annas per ton, leviable on Manganese-ore extracted in the Central Provinces and Bombay.*

F.o.b. price per unit of first-grade ore.	Royalty leviable per ton of ore.
Pence.	*Annas.*
$5\frac{1}{2}$	$\frac{1}{2}$
6	$1\frac{1}{5}$
$6\frac{1}{2}$	$1\frac{4}{5}$
7	$2\frac{2}{5}$
$7\frac{1}{2}$	3
8	$3\frac{3}{5}$
$8\frac{1}{2}$	$4\frac{1}{5}$
9	$4\frac{4}{5}$
$9\frac{1}{2}$	$5\frac{2}{5}$
10	6

On comparison of this table with the corresponding table in the previous Review it will be noticed that the scale of royalties is now based on f.o.b. prices in place of c.i.f. prices. This change was necessitated by the fact that the increased prices of manganese-ore during the war were largely due to increased ocean freights and consequently did not benefit the mining community proportionately (see page 152).

In the Native States a fixed royalty irrespective of price is usually arranged when a prospecting license or mining lease is granted. The rates prevailing in certain States are as follows :—

TABLE 70.—*Royalty, in annas per ton, levied in certain Native States and Zamindari lands.*

	Annas.
Jhabua State, Central India	4
Mysore State	5 per cent. on the pit's-mouth value of the ore subject to a minimum of 10 annas a ton.[1]
Sandur State, Madras	6
The Vizianagram Samasthanum, Madras . . .	4

[1] Ores containing not more than 44 per cent. of manganese are subject to a minimum royalty of only 6 annas.

From table 59 and the diagram (fig. 11) on page 151, it will be seen that the price per unit of manganese, and consequently the price per ton of manganese-ore obtained on its delivery *c.i.f.* at the port of destination, is subject to great variations. Up till November 1909 (*Mining Journal*) the following classification was in use :—

Valuation of manganese-ore.

1st grade	50 per cent. Mn and upwards.
2nd ,, ...	47—50 per cent. Mn.
3rd ,, ...	40—47 per cent. Mn.

But from December 1909 the following schedule was employed :—

1st grade	50 per cent. Mn.
2nd ,, ...	48—50 per cent. Mn.
3rd ,, ...	45—48 per cent. Mn.

and during the war quotations have been given for first-grade ore only.

As an example of the way in which the schedule of prices is applied we can take the case of a 50 per cent. ore from the Central Provinces in December 1914. The average price at this time was 11 pence per unit. The price then paid per ton for this ore would be 50×11 pence=£2—5—10.

The prices given in table 59, apply to ore delivered in the United Kingdom ; and for this scale to be applicable it was formerly necessary that the ore should not contain more than 10 per cent. of silica and 0·10 per cent. of phosphorus.

In the United States before the war a schedule of prices was fixed periodically by the Carnegie Steel Company and one such schedule is quoted in the previous Quinquennial Review. The great rise in prices during the present period led to the announcement in 1918 by the War Industries Board of a revised schedule fixing the price per unit of manganese for each 1 per cent. rise from 35 per cent. upwards. The following is an abstract :—

	Per unit.
35 per cent. Mn.	$ 0·86
40 ,, ...	$ 1·02
45 ,, ...	$ 1·12
50 ,, ...	$ 1·22
54 ,, ... and upwards	$ 1·30

The above prices are based on ore containing not more than 8 per cent. silica or 0·25 per cent. phosphorus and are subject to

premia and penalties for amounts of silica respectively below and above the standard figure, and to penalties for amounts of phosphorus above the standard, no premium being offered for phosphorus below the standard. This illustrates the point referred to in the previous Review that silica appears to be of much greater importance as a deleterious constituent than phosphorus. For details of these premia and penalties reference should be made to page 463 of "*The Mineral Industry*" for 1918.

Valuation for chemical purposes.

The prices noticed above are those relating to manganese-ores intended for use in the iron and steel industry. For ores suited for use in the chemical industries as oxidising agents much higher prices are often obtained. For chemical purposes it is not the percentage of manganese that is of importance, but the percentage of oxygen liberated on treating the ore with acid, *i.e.*, the *available oxygen.* This is usually expressed in terms of the percentage of manganese peroxide, MnO_2. Not only does the percentage of MnO_2 affect the price, but also the ease with which the oxygen is liberated. Further impurities that are soluble in acid, and so cause an unnecessary consumption of it, are deleterious. The best minerals for these purposes are pyrolusite, psilomelane, and hollandite. For the glass industry the ore must be as free as possible from iron. The only Indian pyrolusite yet found sufficiently pure for the glass industry is that of Pali in the Nagpur district. A picked specimen of this giving 95·57 per cent. MnO_2 showed only 0·06 per cent. Fe_2O_3.

Nomenclature of manganese-ores and manganiferous iron-ores.

It is customary to divide the ores of iron and manganese into iron-ores, manganiferous iron-ores, and manganese-ores. The least percentage of manganese in an iron-ore that is usually paid for is said to be 5 per cent. and with less than 5 per cent. of manganese it hardly seems necessary to prefix the adjective 'manganiferous.' The dividing line between manganiferous iron-ores and manganese-ores was formerly taken at 44 per cent. manganese (=70 per cent. MnO_2). Later, ores with as little as 40 per cent. manganese have been termed manganese-ores, and those below this limit manganiferous iron-ores.[1] According to this method one often sees an ore referred to as manganiferous iron-ore that contains much more manganese than iron. Such a difficulty can easily be avoided

[1] In the United States in 1918 the limiting percentage was lowered to 35.

by creating a class for *ferruginous manganese-ores*. Accordingly, in *Memoirs, Geol. Surv. Ind.*, XXXVII, page 500 (1909), the following classification has been proposed. It is applicable to all ores containing over 50 per cent. of Mn+Fe.

—	Mn per cent.	Fe per cent.
Manganese-ores	40—63	0—10
Ferruginous mangense-ores	25—50	10—30
Manganiferous iron-ores	5—30	30—65
Iron-ores	0—5	45—70

Analyses of manganese-ores.

On pages 501 to 509 of the work cited above a series of tables of analyses of Indian ores will be found. A good idea as to the quality of the ores obtained in different parts of India can be gleaned from the range and mean values of these analyses, which are summarised in the two tables 71 and 72. In a few cases the figures given differ somewhat from the analyses of the ores as exported. The most marked exception is the Panch Mahals. The figures given in table 71 relate to outcrop samples taken before the deposits were opened up and without any selection, such as would naturally take place when the ores were worked; the average quality of ore as exported is reported to be manganese 48·5 per cent., silica 7·4 per cent., and phosphorus 0·17 per cent.

Analyses of cargoes of Indian and foreign ores landed at Middlesborough.

In order to show the value of the Indian ores relative to those of foreign countries two tables (73 and 74) are given below showing the limits and averages, respectively, of a large number of cargoes of manganese-ores and manganiferous iron-ores landed during the years 1897-1906 at Middlesborough. They represent not only Indian manganese-ores, but also the manganese-ores of the Caucasus, Brazil and Chile, and the manganiferous iron-ores of Greece and Spain (*viâ* Carthagena). From these figures it will be seen that the Indian ores contain less moisture than those of the other countries. Some of the latter

TABLE 71.—*Range of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	BIHAR AND ORISSA.				BOMBAY.				CENTRAL INDIA.	CENTRAL PROVINCES.		
DISTRICT.	GANGPUR.(a)		SINGHBHUM.		BELGAUM.(b)		PANCH MAHALS.	SATARA.	JHABUA.	BALAGHAT.	BHANDARA.	CHHINDWARA.
Class of ore	Manganese-ore.		Manganese-ore.	Manganiferous iron-ore.	Manganese-ore (some ferruginous).	Manganiferous iron-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.
Number of analyses.	First grade.	Second grade.	3	3	10	2	4	4	5	13	13	9
Manganese .	49—50	45	46 89—48 08	4 23—20·66	31 20—60 85	8 34—12·84	30·20—49 35	37 55—45·62	44 29—48·49	49·08—54·51	49 00—54·07	48·95—54·97
Iron .	7	7—8	1 22—6 10	25 60—41 30	0 10—18 38	47·22—51 88	3 05—6 25	4 40—9·25	5 86—10 40	5 28—9·10	3 86—10·25	5·00—11·77
Silica .	6	8	2·45—8 30	14·70—18·10	0 65—2·50	1 85—2 70	2·80—40·65	2 90—4·75	5 85—11 25	1·62—6·02	2·08—6·50	4·98—10·63
Phosphorus	0 18	up to 0 15	0·27—0·42	0 35—1 18	0 01—0 12	0 02—0·025	0 16—0 25	0 04—0·10	0·165—0·27	0·04—0·24	0 06—0 34	0·06—0·28
Moisture .	..	..	0·55—0·88	1·00—1·40	.	..	0·30—0 40	1 70—2·50	0 20—0·75	0 12—0·85	0·09—1 00	0·00—1 27

(a) Estimated figures by Mr. W. H. Clark.
(b) From analyses, by Messrs Pearson of London, supplied by Mr. C. Aubert.

TABLE 71 (contd.).—*Range of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	CENTRAL PROVINCES—*contd.*				MADRAS.				MYSORE.		
DISTRICT.	NAGPUR.	JUBBULPORE.			SANDUR. (*a*)	VIZAGAPATAM.			SHIMOGA. New Mysore Manganese Company. (*b*)		SHIMOGA. Shimoga Manganese Company. (*c*)
Class of ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.	Manganese-ore and ferruginous manganese-ore.	Manganese-ore and ferruginous manganese-ore.	Supplied by Vizianagram Mining Company. Manganese-ore.	Supplied by Vizianagram Mining Company. Ferruginous manganese-ore.	Manganese-ore. Higher grade.	Manganese-ore. Lower grade (ferruginous).	Manganese-ore and ferruginous manganese-ore.
Number of analyses.	30	3	7	4	6	12	8	7	..	..	9
Manganese .	42·28—56·52	34·53—56·80	6·20—25·60	0·16—1·70	39·47—54·39	32·21—49·05	41·45—49·69	35·43—38·51	44—56	30—44	34·51—56·94
Iron .	2·09—16·34	1·60—10·30	19·17—47·10	42·08—59·90	5·38—19·40	4·80—15·70	2·35—12·90	12·87—19·32	2—10	10—20	4·01—17·25
Silica .	2·90—18·48	1·40—4·79	4·40—23·40	5·21—20·40	0·43—1·00	1·10—10·30	3·05—5·70	4·93—6·90	1—3	2—6	0·22—5·75
Phosphorus	0·04—0·65	0·03—0·46	0·02—0·85	0·04—0·48	0·02—0·03	0·13—0·48	0·26—0·45	0·20—0·45	0·15—0·06	0·01—0·06	0·01—0·14
Moisture .	0·11—1·32	0·39—0·90	0·12—0·65	0·29—0·38	..	0·50—1·55	..	..	about 1	about 1	..

(*a*) From analyses, supplied by Mr. C. Aubert.
(*b*) Estimated figures by Mr. C. S. Fawcett.
(*c*) From analyses, by various chemists, supplied by the late Miss A. E. Dawson.

TABLE 72.—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	BIHAR AND ORISSA.				BOMBAY.				CENTRAL INDIA.	CENTRAL PROVINCES.						
DISTRICT.	GANGPUR.		SINGHBHUM.		BELGAUM.		PANCH MAHALS.	SATARA.	JHABUA.	BALAGHAT.	BHANDARA.	CHHINDWARA.	NAGPUR.	JUBBULPORE.		
Class of ore.	Higher grade.	Lower grade.	Manganese-ore.	Manganiferous iron-ore.	Ferruginous manganese-ore.	Manganiferous iron-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ore.	Iron-ore.
Number of analyses.	Half the limits.	Half the limits.	3	3	10	2	4	4	5	13	13	8	30	3	7	4
Manganese .	49·5	45	47·66	11·84	44·77	10·53	41·68	40·79	46·94	51·88	51·94	52·72	51·53	45·56	20·26	0·96
Iron . .	7	7·5	2·90	34·93	10·33	49·55	4·07	6·94	8·44	7·40	7·27	7·08	6·24 ($\frac{29}{30}$)	4·79	28·78	50·50
Silica . .	6	8	4·63	16·46	1·49	2·27	19·11	3·75	8·14	3·74	4·59	7·16	7·25	2·68	12·99	10·76
Phosphorus .	0·18	0·13	0·34	0·74	0·035	0·023	0·20	0·07	0·20	0·11	0·14	0·14	0·11	0·215	0·25	0·32
Moisture .	..	..	0·63	1·17	..	..	0·35	1·99	0·43	0·37	0·44	0·38	0·49 ($\frac{26}{30}$)	0·56	..	0·336
Manganese + Iron	56·5	52·5	50·56	46·77	55·10	60·08	45·75	47·73	55·38	59·28	59·21	59·80	57·77	50·35	*49·04	51·4

TABLE 72 (contd.)—*Mean of Analyses of Manganese-ores and Manganiferous Iron-ores from the different Districts and Provinces of India.*

PROVINCE.	MADRAS.				MYSORE.		
					SHIMOGA.		
DISTRICT.	SANDUR.	VIZAGAPATAM.			New Mysore Manganese Company.		Shimoga Manganese Company.
			Supplied by Vizianagram Mining Company.		Ferruginous manganese-ore.		
Class of ore	Ferruginous manganese-ore.	Ferruginous manganese-ore.	Manganese-ore.	Ferruginous manganese-ore.	Higher grade.	Lower grade.	Manganese ore.
Number of analyses.	6	12	8	7	3	Half the limits.	9
Manganese	47·75	42·96	44·31	46·75	46·75	37	49·10
Iron	11·45	11·22	9·08	15·20	10·06	15	7·74
Silica	0·61	4·29	4·15	5·72 (?)	1·77	4	2·62
Phosphorus	0·030	0·27	0·32	0·335	0·031	0·035	0·085
Moisture	..	0·90	..	..	0·95	1	..
Manganese + Iron . . .	59·20	54·18	53·42	51·95	56·81	52	56·84

contain such large quantities of moisture—Caucasus, 8·67 per cent.; Brazil, 11·35 per cent.; and Spain, 8·44 per cent.—that it is necessary to reduce the analyses to their condition when dried at 100° C. before any fair comparison can be made. This has been done by assuming that the constituents of the ores not given in the 'as received' columns would if determined make the analyses add up exactly to 100. From the figures representing the dried ores it will be seen that the Indian ores stand first as regards manganese contents, with Brazil a close second; as regards silica, Brazil stands first, with India second: as regards phosphorus, however, India stands last but one, the only ores containing more phosphorus being those of Russia: the Indian ores contain much less iron than the manganiferous iron-ores of other countries; but of the true manganese-ores they contain the highest amounts of iron, in spite of the fact that they also contain the highest amounts of manganese.

The high iron contents of the Indian ores may be regarded as a point in their favour, or otherwise, according to the use to which the ores are to be applied. It is true that the high iron contents make it more difficult to manufacture the very highest grades of ferro-manganese from the Indian ores; but, on the other hand, if the very highest grades are not required, then the iron is of considerable value. Both manganese and iron are of use in this case, and the buyer obtains the following totals of Mn+Fe when he buys the ores of the different countries:—

	Mn+Fe. Per cent.
India	57·17
Brazil	54·09
Russia	50·41
Chile	48·40
Greece	47·99
Spain	44·27

As regards phosphorus, the figures for the Indian ores are rather misleading; for an examination of the analyses from which these figures have been taken shows that the ores consist of two different varieties. The majority of analyses are typical of the ores of the Central Provinces, whilst four of them probably represent ores from the Vizagapatam district. I have accordingly separated them into two groups, of which the mean values are given in table 75. From these figures it will be seen that the Central Provinces ores average 0·096 per cent. and the Vizagapatam ores 0·291 per cent. in phosphorus. With the gradual rise that is taking place in the phosphorus contents of the ores won in the Central Provinces, however it is probable that the average figure given in table 74 now corresponds closely with that for the Central Provinces.

Value of the Indian manganese-ore production.

The valuation of the Indian manganese-ore production is a question of some interest. There are of course several ways of stating the value. Manganese-ore possesses one value per ton as stacked at the pit's mouth, another as delivered *f.o.r.* at the railhead, a third as delivered *f.o.b.* on board the ship at the port of shipment, a fourth as delivered *c.i.f.* at the port of destination, and a fifth after it has been converted into ferro-manganese. For example, with

TABLE 73.—*Limits of Analyses of Cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesborough during the ten years 1897 to 1906.*

COUNTRY.	INDIA.	RUSSIA (CAUCASUS).	BRAZIL.	CHILE.	GREECE.		SPAIN (*viâ* CARTHAGENA).
Class of ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganese-ore.	Manganiferous iron-ores.		Manganiferous iron-ores.
					Raw.	*Calcined.*	
Number of cargoes.	26	77	25	9	54	18	24
Period.	1900—1906.	1898—1906.	1898—1906.	1898—1903.	1897—1906.	1897—1903.	1897—1905.
Manganese	42·13 —54·53	40·74 —48·98	37·05 —48·14	46·44 —49·56	8·63 —24·44	10·41 —23·21	7·32 —21·78
Iron	3·85 —11·69	0·38 — 0·93	2·55 — 8·26	0·25 — 0·52	18·96 —42·75	26·55 —43·75	16·38 —40·75
Silica	2·63 — 9·99	6·91 —13·06	0·80 — 7·78	6·12 — 9·16	2·59 —11·52	5·35 — 9·70	6·50 —17·97
Phosphorus	0·056— 0·331	0·095— 0·17	0·017— 0·130	0·009— 0·018	0·012— 0·044	0·015— 0·038	0·007— 0·022
Moisture	0·21 — 2·64	5·67 —12·35	2·69 —19·57	0·54 — 2·13	0·56 — 8·74	...	4·07 —13·78
Alumina, siliceous matter, etc.	3·63 —13·18	8·97 —15·58	0·92 —12·80	11·92 —13·47	2·74 —12·13	6·20 —10·80	6·18 —19·52

Table 74.—*Mean of Analyses of Cargoes of Manganese-ores and Manganiferous Iron-ores landed at Middlesborough during the ten years 1897 to 1906.*

Country.	India.		Russia. (Caucasus).		Brazil.		Chile.		Greece.			Spain (*viâ* Carthagena).	
Class of ore.	Manganese-ore		Manganese-ore.		Manganese-ore.		Manganese-ore.		Manganiferous iron-ores.			Manganiferous iron-ores.	
									Raw.		*Calcined.*		
Number of cargoes.	26		77		25		9		54		18	24	
Period.	1900—1906.		1898—1906.		1898—1906.		1898—1903.		1897—1906.		1897—1903.	1897—1905.	
Method of reporting analysis.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	As received.	Dried at 100° C.	Dried at 100° C.	As received.	Dried at 100° C.
Manganese . . .	50·49	50·86	45·28	49·58	44·60	50·314	47·51	47·99	16·15	16·96	43·01	19·35	21·13
Iron	6·26	6·31	0·76	0·83	3·35	3·78	0·41	0·41	29·54	31·03	41·32	21·19	23·14
Silica . .	5·67	5·71	9·29	10·17	1·81	2·04	7·26	7·33	7·37	7·74	7·33	11·18	12·21
Phosphorus . . .	0·126	0·127	0·147	0·161	0·040	0·052	0·015	0·011	0·022	0·023	0·023	0·013	0·014
Moisture . . .	0·72	...	8·67	...	11·35	...	1·01	...	4·79	...	...	8·44	...
Alumina, siliceous matter, etc.	6·75	6·80	11·66	12·77	2·73	3·08	12·52	12·65	8·04	8·44	8·35	12·63	13·79

TABLE 75.—*Mean of Analyses of Indian Ores in Table 73 arranged according to Probable Source.*

Source of ore.	Central Provinces, and possibly Jhabua and Panch Mahals.	Vizagapatam.
Number of cargoes.	22	4
Manganese	51·31	45·95
Iron	5·53	10·29
Silica	6·13	3·10
Phosphorus	0·096	0·291
Moisture	0·71	0·76

the price at fourteen pence per unit, the average value of Central Provinces ore may be taken as:—

Rs.	A.	
19	10	at the pit's mouth.
21	2	*f.o.r.*
30	12	*f.o.b.*
43	12	*c.i.f.* with pre-war freights.

The question of values is discussed at length in *Memoirs, Geol. Surv. Ind.*, Vol. XXXVII, Chapter XXV, and it is there shown that to obtain a true idea of the value of the industry to India the export or *f.o.b.* values must be considered. But it is also pointed out that the true value of the ore in the world's markets is the *c.i.f.* value. The export values formerly given were obviously much too low; they were based on figures supplied by the mine operators, and represented, apparently, the cost of winning the ore and placing it on board a ship at the port, and not the true value of the ore, which is the *c.i.f.* value *minus* charges incurred from the port of shipment to the port of destination. In the work already cited the export values have been re-calculated from the beginning of the industry. First the *c.i.f.* values per ton have been calculated separately for each area, on the basis of the average market price per unit of manganese-ore during the year, and an assumed average composition of the ores. From these *c.i.f.* values the *f.o.b.* values are obtained by deducting freights *plus* destination charges from the *c.i.f.* value

per ton. The *f.o.b.* value per ton is then multiplied by the actual production for the year. The figures thus calculated for the years 1914 to 1918 are given in table 76.

Usually the amounts of ore won and exported are not very different; but during some years, as in 1914, 1917, and 1918—three out of the present quinquennium—the amounts of ore won exceed greatly the amounts of ore exported, and the totals obtained as above are considerably more than the total values actually obtained by the mining community. As figures for the amounts of ore exported are not obtainable in detail province by province the totals may be adjusted for these years by valuing the exports for the calendar years ending 31st December at the average value per ton derived from the total production. Treated in this way the total values for 1914 to 1918 become—

	£
1914	775,220
1915	867,010
1916	1,372,248
1917	1,238,605
1918	1,008,932

and these figures have been used in the table of total values (table 1, page 10).

Comparing the export values of the manganese-ore production with the values for the other chief Indian mineral products given in table 1 it will be seen that manganese has been displaced by petroleum from third to fourth place.

Manufacture of ferro-manganese in India.

In previous reviews reference has been made to the potential loss that India suffers through exporting her manganese-ore in the raw condition, instead of converting at least a portion of it into ferro-manganese in the country. It is satisfactory, therefore, to be able to record that during the present quinquennium the manufacture of ferro-manganese has been inaugurated in India. On account of the great increase in the price due to the war, one of the blast furnaces at Sakchi was diverted to the manufacture of ferro-manganese in October 1915, and up to the end of that year 2,658 tons of alloy were made of the following composition:—

	Per cent.
Manganese	65—75
Phosphorus	0·6— 0·8
Silicon	2— 0·60

TABLE 76.—*Export values f.o.b. at Indian Ports of the Manganese-ore produced in India in the years 1914 to 1918.*

Year.	Bihar and Orissa.	Bombay.	Central India.	Central Provinces.	Madras.	Mysore.	Totals	Totals sterling.	Value per ton.
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	£	£
1914	1,14,192	5,12,133	92,158	1,13,68,411	7,98,989	2,73,082	1,31,58,965	**877,264**	1·284
1915	14,894	7,90,628	8,372	1,25,53,577	6,264	5,69,453	1,39,43,187	**929,546**	2·064
1916	90,334	17,81,047	...	1,98,98,629	43,391	4,91,992	2,23,05,393	**1,487,026**	2·304
1917	4,13,733	9,41,968	...	2,04,54,719	27,963	6,77,817	2,25,16,201	**1,501,080**	2·541
1918	6,37,455	14,85,705	...	1,94,09,289	50,733	6,42,836	2,22,26,018	**1,481,735**	2·861
TOTAL . .	**12,70,608**	**55,11,481**	**1,00,530**	**8,36,84,625**	**9,27,349**	**26,55,180**	**9,41,49,764**	**6,276,651**	
Average .	*2,54,122*	*11,02,296*	*20,106*	*1,67,36,925*	*1,85,468*	*5,31,036*	*1,88,29,953*	*1,255,330*	*2·172*

Subsequently the average composition of the ferro-manganese produced was :—

	Per cent.
Manganese	70
Phosphorus	0·55—0·66
Silicon	2—3

the average output from one furnace being about 80 tons a day. In 1917 the manufacture of ferro-manganese at Sakchi was discontinued on account of the necessity of keeping both blast furnaces on the production of pig-iron required for the manufacture of steel. But from November of the same year one of the smaller blast furnaces of the Bengal Iron and Steel Company at Kulti has been producing ferro-manganese with a guaranteed minimum of 74 per cent. manganese and maximum of 0·55 per cent. phosphorus. The average monthly output has been given as 1,150 tons, and the balance left over after satisfying the requirements of Sakchi, is exported, the total exports (to France, United States, Italy, and Natal) up to the end of August 1918 being 7,555 tons. The production of ferro-manganese in India during the quinquennium is shown in table 77.

TABLE 77.—*Production of Ferro-manganese in India during the years 1915 to 1918.*

Year.	Tata Iron & Steel Co.	Bengal Iron & Steel Co.	Totals
	Tons.	Tons.	Tons.
1915	2,658	...	2,658
1916	1,843	...	1,843
1917	1,475	2,257	3,732
1918	...	12,114	12,114
TOTALS	5,976	14,371	20,347

The ore used at Sakchi was railed from the company's mines in the Central Provinces, the average composition of the ore railed during 1917 being as follows :—

	Per cent.
Manganese	50·41
Iron	6·38
Silica	4·36
Phosphorus	0·041

That smelted at Kulti was purchased from the Central Provinces Prospecting Syndicate, but figures of composition have not been obtained.

The composition of the coke used at the two works was as follows :—

—	Sakchi.	Kulti.
	Per cent.	Per cent.
Moisture	6·54	2·2
Volatile matter	1·63	7
Fixed carbon	72·28	..
Ash	19·53	20
Sulphur	0·64	..
Phosphorus in ash	0·935	..

As will be seen from the figures given above the phosphorus contents of the alloy produced at Sakchi and Kulti were considerably higher than the figure 0·30 per cent. representing the upper limit of phosphorus acceptable abroad in normal times. With a careful selection of Indian ores (*e.g.*, of the composition of that already smelted at Sakchi, or ore from Balaghat running 0·07 per cent. phosphorus) and the use of Giridih coke running only 0·022 per cent. phosphorus, ferro-manganese could be produced with phosphorus within this figure. But considering that the amount of Giridih coke is limited, that Indian cokes are normally high in phosphorus, and that the percentage of phosphorus in the high-grade manganese-ores of the Central Provinces is slowly increasing with depth from the surface, it is evident that India can never be a large producer of low-phosphorus ferro-manganese by blast-furnace methods. The possibilities of the electric production of such low-phosphorus alloy deserve, therefore, careful consideration.

The fact that ferro-manganese is now being made in India renders it important to secure statistics of the amounts of manganese-ore railed to Sakchi and Kulti and consumed in India, in order to enable one to deduce what portion of the difference between the figures of production of manganese-ore in India and exports thereof represents accumulated stocks. The figures for ore railed to Sakchi are as follows :—

Year.	Tons.
1914 (up to and including)	16,693
1915	21,065
1916	5,645
1917	*Nil*
1918	9,182
TOTAL	52,585

The figures for Kulti are not available, but judging from the quantity of ferro-manganese manufactured, the amount of ore railed to Kulti must have been sufficient to raise the total of ore consumed in India to from 90,000 to 100,000 tons.

Other economic considerations.

The thoroughness with which India was prospected for deposits of manganese-ores during the first 8 years or so of this century is shown by the fact that, during the previous quinquennial period, 1909-13, no fresh fields of importance were discovered, nor were any new deposits of importance located in areas already under exploitation; whilst during the present period one fresh deposit only has been opened up, namely Pani in Chhota Udepur, Bombay Presidency, the initial production of which dates from 1914.

As before work has been continued almost everywhere on open-cast lines, but in two cases at least underground mining has been commenced. One is at Kandri in the Nagpur district, where a beginning has been made by driving in from the foot of North Hill along the strike of the ore-band; the other is at Gariajhor in Gangpur State, where the thin portion of the ore-band in Prichard Hill is being regularly mined, with rock-filling of the stopes.

With regard to the effects on output of the steadily increasing depth of the Indian manganese quarries, as would be expected, deposits of superficial origin, such as those of Vizagapatam, are, with the passage of years, giving a markedly decreased yield. But deposits of the gonditic type (chiefly in the Central Provinces) show no evidence of deterioration in depth, except when structural factors intervene; and except for the very slight decrease in manganese contents and slight rise in silica and phosphorus contents that characterise many of these deposits, which features may, as noted in the previous Review, be regarded as evidence of a certain amount of surface modification of these ores, originally consolidated in depth. With the continuous output of ore still yielded by so many of the Central Provinces deposits the mining companies have not yet been impelled to test, by boring, the continuity of their deposits in depth.

During the period one deposit of gonditic type has been abandoned, namely, Kajlidongri in Jhabua State. Opportunity to revisit the locality has not occurred, so that the cause of this abandonment has not been ascertained, but it is presumably structural, connected with the repeated folding of the ore-band (see *Mem. Geol. Surv. Ind.*, XXXVII, plate 19). From the commencement of work this deposit

has yielded 195,763 tons of ore, besides affording to the mineralogist many rare specimens.

The year 1919 saw the abandonment of a second valuable gonditic deposit, namely, Sitapar in the Chhindwara district. This deposit was worked from a large open quarry, until at about 100 feet from the surface the ore-body was truncated by felspathic intrusives. The circumstances render it possible that the remainder of the ore-body may lie concealed underground in one or more fragments. As several of the ores of manganese are distinctly magnetic, though usually only slightly so, it seems desirable to determine the possibilities of magnetometric surveying in locating the position of underground bodies of manganese-ore. The prospects of success in such application of these methods do not seem very bright; but this much has been already ascertained, that a dipping-needle set up directly on a manganese-ore deposit is often strongly affected thereby.

From the commencement of work in 1906 until the end of 1918 the Sitapar deposit has yielded 66,212 tons of ore of exceptionally high grade, and in addition no less than three minerals new to science (see also page 189).

Geological Relations of Indian Manganese-ores.

In view of the importance of the Indian manganese industry it is proposed to repeat below, with such slight alterations as are necessary, the brief sketch of the distribution and mode of occurrence of the Indian deposits given in the previous Review. The deposits of economic value can be divided into three main groups.—

(*A*) Deposits associated with a series of manganiferous intrusives known as the *kodurite* series. Found in—

Madras :—Ganjam, *Vizagapatam*.

(*B*) Deposits associated with rocks of Dharwar age—the manganiferous facies of which is known, when containing spessartite-garnet, as the *gondite* series. Found in—

Bihar and Orissa :—*Gangpur*.
Bombay :—Narukot, *Panch Mahals, Chhota Udepur*.
Central India :—*Jhabua*.
Central Provinces :—*Balaghat, Bhandara, Chhindwara, Nagpur* and Seoni.

(C) Deposits occurring as *lateritoid* replacement masses on the outcrops of Dharwar rocks. Found in—

Bihar and Orissa :—*Singhbhum.*
Bombay :—Dharwar, North Kanara, Ratnagiri.
Central Provinces :—*Jubbulpore.*
Goa.
Madras :—*Bellary, Sandur.*
Mysore :—*Chitaldrug, Kadur, Shimoga, Tumkur.*

(Italics denote that ore has been worked for export.)

In addition to the occurrences noted above, ore has been worked in the low-level laterite of Goa and the high-level laterite of Belgaum (though this occurrence—Talevadi—might perhaps be more accurately classed with the lateritoid occurrences). Manganese-ores have also been found in many other districts in India, but none of these other occurrences has been shown to be of any value. Amongst them, the following may be mentioned :—

In Bijawar rocks :—Dhar, Gwalior, Indore, Hoshangabad.
In Vindhyan rocks :—Bhopal.
In Kamthi rocks :—Yeotmal.
In Lameta rocks :—Dhar, Indore, Nimar.
In lateritic soil on the Deccan Trap :—Satara.

Each of the three chief groups will now be considered in turn.

A.—The Kodurite Group.

Kodurite series.

The Kodurite series[1] is developed typically in the Vizagapatam district, where it occurs associated with other Archæan crystalline rocks, the chief groups of which are the khondalite series including the calcareous gneisses, the gneissose granite, and the charnockite series. The kodurite series is held to be of igneous origin, and probably of later age than the khondalite series, which is the series with which it is closest associated. The original koduritic magma has been differentiated into a series of rocks ranging from very acid (quartz-orthoclase-rock) through basic (kodurite) to ultra-basic (spandite rock and manganese pyroxenites). The typical rock, *kodurite*, is composed of potash-felspar, spandite (a garnet intermediate in composition between spessartite and andradite), and apatite. The manganiferous nature

[1] *Mem. Geol. Surv. Ind.*, XXXVII, Chaps. XII, XIII (1909); *Rec. Geol. Surv. Ind.*, XXXV, p. 22 (1907); *op. cit.*, XLII, p. 208 (1912); *op. cit*, XLIII, p. 42 (1913).

of these koduritic rocks has been a petrological surprise, and it has consequently been suggested[1] that they may be hybrid rocks produced by the assimilation by an acid igneous magma of manganese-ore bodies and manganese-silicate-rocks allied perhaps to the gondite series.

The manganese-bearing minerals contained in these rocks are spandite, rhodonite, and two or three other manganiferous pyroxenes, at present unnamed. Subsequently, the whole series of rocks has been chemically very much altered with the production from the felspar of enormous masses of lithomarges and, from the manganiferous silicates, of manganese-ores. Other secondary products are chert, ochres, and wad.

Vizagapatam: mode of occurrence.

The manganese-ore bodies thus formed are often extremely irregular both in shape and size, often showing no definite strike or dip. But in other cases, as at Garbham, the ore-bodies have a well-marked dip and strike, and apparent bedding, which probably represents original banding in the parent rock; for much of the ore has been deposited so as to replace metasomatically the pre-existing rock.

Dimensions of ore-bodies.

Some of the ore-bodies are of very large size. The largest, Garbham, is some 1,600 feet long, and 167 feet thick at its thickest section 100 feet of this thickness being ore and the remainder lithomarge, wad, etc. From the commencement of work on this deposit in 1896 to the end of 1918, Garbham has yielded the large total of 775,805 tons of ore. The only other very large deposit in this district is Kodur; but this is really a series of scattered ore-bodies in lithomarge. It has yielded 384,445 tons of ore from 1892 to 1918. It was the first manganese-ore deposit to be worked in India.

Composition of ores.

The ores of the Vizagapatam district are composed mainly of psilomelane with subordinate amounts of pyrolusite, braunite, manganmagnetite, and in one case (Garividi) vredenburgite. They are usually second and third grade—although some first-grade ore has been obtained at Kodur—and can be divided into manganese-ores (above 40 per cent. Mn) and ferruginous manganese-ores (below 40 per cent. Mn). They are characterised by high iron and phosphorus contents, and comparatively low silica (see table 70).

[1] *Rec. Geol. Surv. Ind.*, XLV, p. 102, (1915).

B.—The Gondite Group.

The gondite series.

The gondite series[1] is composed of metamorphosed manganiferous sediments of Dharwar age, and is characterised by the presence of various manganiferous silicates, the most important of which are the manganese-garnet, spessartite, and the manganese-pyroxene, rhodonite. The garnet occurs commonly as a rock composed of spessartite and quartz, and this is the rock that has been called *gondite,* after the Gonds, one of the aboriginal races of the Central Provinces. Other common rocks are spessartite-rock, rhodonite-rock, and rhodonite-quartz-rock. The series is developed typically in the districts of Balaghat, Bhandara, Chhindwara, and Nagpur, in the Central Provinces, but has also been found in several other areas, namely:—Narukot State in Bombay, Jhabua in Central India, Gangpur State in Bihar and Orissa, and probably in Banswara State in Rajputana. It exists also in the Seoni district, Central Provinces.[2]

Forming an integral portion of the same masses of rock as the gonditic rocks, there are, at many places, bodies of manganese-ore, often of large size and first-rate quality, some of the manganese-ore deposits of the Central Provinces being the most valuable in India, and second to none found in other parts of the world.

Origin.

The rocks of the gondite series are supposed to have been formed by the metamorphism of a series of sediments deposited during Dharwar times. These sediments were partly mechanical (sands and clays) and partly chemical (manganese oxides). When these sediments were metamorphosed, the sands and clays were converted into quartzites, mica-phyllites and mica-schists; the purest of the manganese-oxide sediments were compacted into crystalline manganese-ores; whilst mixtures of the mechanical sediments, sand or clay, with the chemical sediment, manganese oxide, were converted into rocks composed of manganese silicates—spessartite and rhodonite—any silica left over, after accounting for the formation of these minerals, appearing as quartz. [The effects of regional metamorphism have been in some cases complicated by contact effects with resultant hybridism due to later intrusives.[3]] The rocks thus formed constitute the *gondite series.* There is abundance of evidence to prove that the manga-

[1] *Mem. Geol. Surv. Ind.,* XXXVII, pp. 306—365.
[2] R. C. Burton, *Rec. Geol. Surv. Ind.,* XLIV, p. 21 (1914).
[3] L. L. Fermor, *Rec. Geol. Surv. Ind.,* XLV, p 104 (1915).

nese-silicate-rocks of the gondite series have been subjected to extensive oxy-alteration, subsequent to their formation, but probably in Archæan times. As a result of this alteration large bodies of manganese-ore have been formed; no decisive evidence has yet been obtained indicating the relative proportions of the workable ores that are the result of the direct compression of the purer portions of the original manganese-oxide sediments[1] and of the ores that have been formed by the subsequent alteration of the rocks of the gondite series.

Nagpur-Balaghat area: mode of occurrence.

The ore-bodies thus formed occur as lenticular masses and bands intercalated in the quartzites, schists, and gneisses; and, as would be expected from the suggested mode of origin, the ore is frequently found to pass, both laterally and along the strike, into the partly altered or quite fresh members of the gondite series, the commonest rock being gondite itself. The ore-bodies are often well-bedded parallel to the strike of the enclosing rocks, and several of them are often disposed along the same line of strike, indicating that they have probably all been produced from the same bed of manganiferous sediment. A good example of such a line of deposits is one in the Nagpur district, stretching from Dumri Kalan in an easterly direction as far as Khandala, a total distance of 12 miles, this line including the valuable deposits of Beldongri, Lohdongri, Kacharwahi, and Waregaon. With the enclosing rocks the ore-bodies have often suffered repeated folding, upon which is often superposed a well-marked pitch.

Dimensions of ore-bodies.

The ore-bodies often attain great dimensions. The Balaghat deposit is 1¾ miles long; at Manegaon in the Nagpur district the ore-body is 1½ miles long; whilst the band running through Jamrapani, Thirori, and Ponia, in the Balaghat district, is exposed more or less continuously for nearly 6 miles. In an earlier review a thickness of 100 feet (of ore) was ascribed to the Kandri deposit, and of 1,500 feet (ore and gonditic rocks) to the Ramdongri deposit. Subsequent work indicates that both these deposits are folded, and

[1] The fact that some of the gonditic manganese-ores are of great antiquity (at least pre-pegmatite in age) was conclusively proved by the discovery of a detached fragment of ore in pegmatite cutting the Gowari Warhona manganese-ore deposit, Chhindwara district. See *Rec. Geol. Surv. Ind.*, XLI, pp. 1—11 (1911) Similar phenomena were later well displayed at Sitapar in the same district, and are still to be seen at intervals at Kachhi Dhana.

there is no evidence that the ore-bodies are anywhere more than 45 to 50 feet thick: greater apparent thicknesses appear to be due to duplication by folding. On the other hand the ore-band is often much thinner, but may have again attained a fictitious thickness due to folding. The depth to which these ore-bodies extend is unknown. It is, however, almost certain that, in many cases, they extend to at least 100 to 400 feet below the outcrop, *e.g.*, some of the deposits occupying hills in the Central Provinces; and it is very probable that some of the Central Provinces deposits extend to depths considerably greater than these; for the evidence obtained indicates that the deposits were formed in depth, so that the position of the deposit bears no genetic relation to that of the surface. An idea of the size of some of these deposits can be obtained from the amounts of ore they have yielded, as shown in the following table :—

TABLE 78.—*Total Production of Manganese-ore from Deposits of Gonditic Type that have yielded 100,000 tons by the end of 1918.*

—	Mine.	District or State in which situated.	Year of commencement of work.	Total production to end of 1918.
				Tons.
1	Balaghat . .	Balaghat . .	1901	1,069,192
2	Kandri . . .	Nagpur . .	1900	670,281
3	Chikhla (with Yedarbuchi).	Bhandara . .	1901	638,196
4	Thirori . . .	Balaghat . .	1902	503,194
5	Kachi Dhana .	Chhindwara . .	1906	441,740
6	Mansar . . .	Nagpur . .	1900	438,023
7	Lohdongri . .	Do. . .	1900	268,161
8	Gariajhor . .	Gangpur . .	1908	217,135
9	Kodegaon . .	Nagpur . .	1903	214,219
10	Miragpur . .	Bhandara . .	1905	199,976
11	Kajlidongri . .	Jhabua . . .	1906	195,763
12	Sukli . . .	Bhandara . .	1905	191,620
13	Gumgaon . .	Nagpur . .	1901	184,560
14	Ukua (with Gudma and Samnapur).	Balaghat . .	1906	135,891
15	Kosumba . .	Bhandara . .	1905	107,161
16	Shodan Hurki .	Balaghat . .	1912	105,783
17	Kacharwahi . .	Nagpur . .	1902	103,901
18	Ramrama . .	Balaghat . .	1906	103,853
19	Junawani . .	Nagpur . .	1906	102,167

The total production from deposits of the gonditic type (the Central Provinces, Jhabua, and Gangpur) averaged 504,597 tons

annually during the quinquennium as compared with 529,152 tons annually during the previous quinquennium.

Composition of ores.

The typical ores of the Nagpur-Balaghat area of the Central Provinces consist of mixtures of braunite and psilomelane of different degrees of coarseness of grain. The most typical ore is a hard fine-grained ore composed of these two minerals. Other minerals found in the Central Provinces ores are hollandite, vredenburgite, sitaparite, and rarely pyrolusite. The unique ore of Sitapar in the Chhindwara district consisting of hollandite with sitaparite and fermorite, proved to be a surface form, and at a depth of 60 feet gave place almost entirely to braunitic ore, which persisted to the bottom of the pit at 100 feet (see page 183). The ores exported from the Central Provinces are nearly all of first grade, although at times of high prices, a small quantity of second-grade ore is exported. The chief characteristics of these ores are the high manganese contents (usually 49 to 54 per cent. as exported), moderately high iron (usually 4 to 8 per cent.), rather high silica (usually about 6 to 9 per cent., and largely due to the braunite in the ore), and moderately low phosphorus (about 0·07 to 0·17 per cent.). For analyses see table 71, page 170.

Ores in crystalline limestones.

In addition to the deposits found in association with spessartite- and rhodonite-bearing rocks in the Central Provinces, manganese-ores are sometimes found in association with crystalline limestones, usually containing piedmontite, and also regarded as of Dharwar age. Ores of this character are found characteristically in the Nagpur and Chhindwara districts. The manganese-ores occur either as lines of nodules or as fairly definite beds in the limestone, the latter being the rarer mode of occurrence. In most cases it is not found profitable to work these ores; but where the bed of ore is of greater thickness than usual, as in the Junawani forest, it may pay at times of high prices; whilst patches of residual nodules accumulated during the dwindling of limestones will pay to work at any time, if not too far removed from transport facilities. The ores found thus are usually composed of braunite and psilomelane or hollandite. These ores, and the associated crystalline limestones and calcareous gneisses, are probably the products of the metamorphism of calcareous sediments with associated manganiferous ores, and are thus analogous in origin to the ores associated with the true gonditic rocks.

The remarks in the foregoing paragraphs apply particularly to the deposits found in the Central Provinces, but also in a general way to the deposits found associated with rocks of the gondite series in other parts of India. A few remarks about these are given below.

Gangpur, Bihar and Orissa.

During 1908 the extension of the gondite series into Bihar and Orissa was proved by the discovery of manganese-ore deposits in Gangpur State associated with rocks containing spessartite and rhodonite. The ores are typical gonditic ores, containing braunite in a matrix of psilomelane. Some 200,000 tons of ore have been won at Gariajhor during the years 1908 to 1918. The greatly decreased output during the present quinquennium (a total of 37,662 tons) compared with that during the previous five years (a total of 160,558 tons) was due partly to the exhaustion of the easily-won upper portions of the deposit, and partly to a stoppage of work on the death of the original lessee, Babu Madhu Lal Doogar. In 1916 the Gangpur properties were taken over by the New Gangpur Mining Company, and with a revision of methods of work, including underground mining at one point, the output is again expanding (see table 61). As will be seen from the figures summarised in the following table, the quality of the ore is similar to that of the Central Provinces:—

—	1909.		1919.	
	Limits of analyses.	Mean of analyses.	Two analyses of ore exported.	
Manganese	47·64 —54·13	50·53	49·18	46·45
Iron	5·53 — 6·35	5·85	5·81	4·58
Silica	2·6 — 8	5·7	4·86	10·42
Phosphorus	0·018— 0·143	0·089	0·20	0·10
Moisture	0·78 — 1·16	0·96	..	...

The 1909 figures, supplied by the late Mr. I. Shrager, relate to cargoes shipped during that year, the manganese and phosphorus figures representing eight analyses on a total of 3,600 tons of ore and the other constituents four analyses on a total of 1,600 tons of

ore. The 1919 figures, supplied by Mr. W. H. Clark, represent the first and second grade ore as at present exported. The estimated average figures are given in table 71. These two sets of figures are of interest as illustrating the increase of phosphorus contents in gonditic ores with depth from the surface.

Narukot, Bombay.

Rocks of the gondite series with associated manganese-ore have been found in a small hill at Jothvad in Narukot State, Bombay. The occurrence is of no economic importance, but of great scientific interest. The rock surrounding the hill is a porphyritic biotite-granite presumably of Archæan age, and apophyses from this pierce the gonditic rocks of the hill. Isolated pieces of gonditic rock are included in the granite, and amongst these inclusions are pieces of manganese-ore, proving that a portion at least of the manganese-ore had been formed before the time of intrusion of the granite into the Dharwar rocks of the area.

Panch Mahals.

Manganese-ore deposits are being worked near Sivarajpur and Bamankua in the Panch Mahals. The rocks with which they are associated are Champaners, that is Dharwars; no rocks of gonditic nature have been found in this area, but it seems, judging from reports, that although a portion of the ores has certainly been formed by the superficial replacement of quartzites, a portion may have been deposited contemporaneously with the enclosing Dharwar rocks; in this case the deposits may be classified with the gonditic deposits. The absence of gonditic rocks would then mean that the rocks—as at the Balaghat deposit in the Central Provinces—had not been subjected to such intense metamorphism as that which produced the gonditic rocks associated with most of the Central Provinces deposits. 379,416 tons of ore have been won from this area in the thirteen years 1906 to 1918. The average composition of this ore as exported is:—

—	Shivrajpur	Bamankua.
Manganese	48·5	48·5
Silica	6	10
Phosphorus	0·19	0·23

Jhabua, Central India.

The chief deposit in Jhabua State is that situated at Kajlidongri. This is a true gonditic occurrence, and the rocks associated with the manganese-bearing rocks are those known as Aravallis, which are in this part of India the equivalents of the Dharwars. In the 11 years 1903 to 1913 this deposit has yielded nearly 190,000 tons of manganese-ore, but during the present quinquennium only an additional 7,000 tons have been won, and since 1916 the deposit has been abandoned (see page 156). For the quality of the ore see table 71.

C.—The Lateritoid Group.

Lateritoid deposits.

In several parts of India manganese-ore deposits are found on the outcrops of rocks of Dharwar age, associated with the latter in such a manner as to leave little doubt that the ores have been formed by the replacement at the surface of Dharwar schists, phyllites, and quartzites. The masses of ore thus formed do not consist entirely of manganese-ore, but often contain considerable quantities of iron-ore; and every gradation is to be found from manganese-ores, through ferruginous manganese-ores and manganiferous iron-ores, to iron-ores. The masses of ore thus formed are often more or less cavernous and bear considerable resemblance to ordinary laterite. In fact some geologists would designate such occurrences by this term; but others would object: and, therefore, to obviate this difficulty the term *lateritoid*—meaning *like laterite*—has been introduced to designate this class of deposit. Lateritoid deposits are, then, irregular deposits of iron and manganese-ores, occurring on the outcrops of Dharwar rocks, and resembling in their cavernous and rugged aspect masses of ordinary laterite. When the rock replaced is a schist or phyllite, it is usually found altered to lithomarge below the capping of ores. The mineral composition of the ores thus formed is usually fairly simple. The manganese-ores are pyrolusite, psilomelane, wad, and more rarely pseudo-manganite, and manganite; whilst the iron ores are limonite and earthy hematite. The harder crystalline minerals—braunite, vredenburgite, sitaparite, magnetite, and specular hematite—are found rarely or never in the lateritoid ores. Hollandite may sometimes occur. The chemical characteristics of the manganese-ores are high iron, low silica, and often very low phosphorus. The manganese is usually correspondingly low, so that the ores won consist mainly of second-grade

manganese-ores and third-grade ferruginous manganese-ores. Such deposits will be worked to the greatest advantage when a market can be found for the iron-ores and manganiferous iron-ores, as well as for the manganese-ores.

Singhbhum and Jubbulpore.

The areas where ores of this nature have been found are given on page 184. Singhbhum and Jubbulpore have yielded small quantities of merchantable ore, but the most important of the lateritoid areas are Mysore and Sandur. A large number of deposits, many of them of large size, have been located in the Sandur Hills, mostly perched up on the edge of the hills at an average elevation of about 1,000 feet above the plains. When transport difficulties have been surmounted, these deposits may be expected to yield large quantities of second-grade and third-grade ores, with possibly a certain proportion of first-grade ore from the Kamataru portion of the State. The deposits are being worked by the General Sandur Mining Company, Ltd. During the years 1905 to 1913, 384,781 tons of ore were won from these deposits, mainly from the Ramandrug and Kannevihalli areas, but after an output of 33,643 tons in 1914, work was closed down during the war on account of the high ocean freights. For analyses see table 71, page 171. The manganese-ore deposits of Mysore are numerous, but very few of them can compare in size with those of the Sandur Hills, although they have been formed in the same way. The chief exception is the Kumsi deposit in the Shimoga district, from which some 160,000 tons of ore were won in the three years 1906 to 1908. In the preceding quinquennium there was a great decline in output compared with that of the initial period of work 1906 to 1908. The present period has not witnessed a serious continuance of this decline, the average annual output being 24,205 tons as compared with 28,280 tons for the previous period. The reduction of the industry to the lower level of the last 10 years is largely due to the superficial nature of the deposits leading to early exhaustion of the best class of ores, whilst high railway and sea freights prevent the exploitation of the lower-grade ores. The chief companies at work in this State were the Workington Iron Company, Ltd., operating in the Shimoga district; the Peninsula Minerals Company of Mysore, Ltd., operating in the Chitaldrug and Tumkur districts.

Sandur.

Mysore.

The Laterite Group.

Goa and Belgaum.

Manganese-ores are sometimes found in true laterite; but such ores are rarely of much economic value. The ores of Goa (Portuguese India) occur in part in this way (in low-level laterite), as also those of Belgaum (in high-level laterite). They are not economically of great importance, owing to the irregular manner in which they occur, and their extremely variable composition. Picked ores, however, are similar in composition to the picked lateritoid ores. Only 598 tons of ore won in Goa were exported from Mormugao during the period 1914-18 as compared with 16,243 tons in the previous quinquennial period. These exports are of course, excluded from table 64.

No figures have been obtained of the production of manganese-ore in Goa during the present period.

Mica.

[G. H. TIPPER.]

The period under review covers most of the war. During 1914 production was almost the same as in 1913. After the outbreak of war, disturbed conditions and uncertainty as to the future of the market caused the closing down of many mines and production decreased by 40 per cent. during 1915. In 1916 the value of mica as a munition product became better realised and the demand for the better qualities of ruby mica from Bihar became insistent. A Government buying scheme was instituted and all stocks unduly withheld were requisitioned. Efforts were made to increase production, which rose almost to its pre-war figure. During 1917 and 1918 the demand for munition purposes became still more urgent. Every effort was made to stimulate production. Prices were regulated by the Munitions Board in London and shipments were not allowed except to the United Kingdom. Restrictions were placed on the manufacture and shipment of splittings. In two areas mining operations were carried out on behalf of Government.

The main demand being for the better grades of ruby mica, production in Madras was generally small, with the exception of 1916. Rajputana, where the output had been continually decreasing, in 1918 received a new lease of life from operations in the States of Gwalior and Udaipur.

The figures for the provincial production are given in table 79.

TABLE 79.—*Provincial Production of Mica for the years 1914 to 1918.*

PROVINCE.	1914.	1915.	1916.	1917.	1918.	*Average.*
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
Bihar and Orissa	33,275	22,195	26,819·8	34,137	45,607·5	32,406·8
Madras . .	5,989·5	3,894	15,675	6,050·4	6,544·7	7,630·7
Rajputana .	1,192·1	1,042	887	720·2	2,250	1,218·3
Mysore . .	50	8·7	18	...	17·9	18·9(*a*)
(Gwalior State)	...	...	...	...	290·2	58(*a*)
TOTAL .	**40,506·6**	**27,139·7**	**43,399·8**	**40,907·6**	**54,710·3**	**41,332·7**

(*a*) Average of 5 years.

TABLE 80.—*Exports of Indian Mica during the years 1914-15 to 1918-19.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	£
1914-15	32,972	*191,066*	5·79
1915-16	33,717	*208,496*	6·08
1916-17	59,521	*341,255*	5·73
1917-18	65,729	*575,285*	8·75
1918-19	55,992	*598,971*	10·69
Average .	49,586	*383,015*	7·72

TABLE 81.—*Exports of Mica for the years 1914-15-to 1918-19.*

YEAR.	BIHAR AND ORISSA.			BOMBAY.			MADRAS.		
	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.
	Cwts.	£	£	Cwts.	£	£	Cwts.	£	£
1914-15 .	25,344	153,618	6·06	2,080	5,986	2·88	5,548	31,462	5·67
1915-16 .	27,117	178,880	6·60	1,455	4,608	3·17	5,145	25,008	4·86
1916-17 .	52,890	297,579	5·62	1,049	3,332	3·17	5,582	40,344	7·22
1917-18 .	55,946	521,533	9·32	3,761	6,697	1·78	6,022	47,055	7·81
1918-19 .	46,446	532,384	11·46	1,438	11,045	7·68	8,108	55,542	6·85
Average .	*41,549*	*336,799*	8·10	*1,957*	*6,314*	3·23	*6,081*	*39,882*	6·56

Exports.

Table 80 shows the quantity and value of the mica exported during the quinquennium, the average being 49,586 cwts., or 2,479 tons, of an average value of £7·7 per cwt. The average quantity during the period 1909-1913 was 45,381 cwts., or 2,269 tons, of an average value of £4·85.

Internal consumption.

In the review of the preceding period attention was drawn to the astonishing fact that there had been, during that period, a considerable excess of exports over production amounting to some 66,000 cwts. It may therefore be safely assumed that at the beginning of the present quinquennium there were no large stocks of mica in reserve in the country. In spite of this, exports were again greatly in excess of production during the present period, the excess amounting to 41,267 cwts., giving an average of 8,253 cwts. To this figure must be added the amount absorbed for internal consumption. The latter has been estimated at 2,000 cwts. per annum; there is reason to believe that this is an over-estimate as with the exception of a limited use for decorative and ornamental purposes there are no industries needing large supplies of mica.

There are two causes which contribute to the above-noted peculiarity of mica mining. In the Bihar mica belt large areas are privately owned and on many of these properties it is customary to lease to numbers of petty contractors of whose methods of work the less said the better. The output so obtained is rarely or never reported and in the aggregate is sufficient to account for a great part of the excess of exports over production. For the rest theft unquestionably accounts for a much larger proportion of mined mica not being reported than is ordinarily supposed.

In general these two causes are chiefly operative in the Bihar belt. In the Nellore district theft is practically unknown while the amount of non-government mica land is much less.

Distribution of mica exported.

Conditions were so abnormal during the period under review owing to restrictions on shipment to any other country than the United Kingdom that a table showing the distribution of exported mica would be of little value. Table 82 is repeated therefore from the previous Review as it covers the last period of normal trade.

Table 82.—*Average Distribution of Indian Mica exported during the years 1908-09 to 1913-14.*

Exported to	Average quantity.		Average value.		Value per cwt.
	Cwts.	*Per cent. of total.*	£	*Per cent. of total.*	£
United Kingdom . .	25,133	*55·4*	130,102	*59·04*	5·17
United States . . .	7,689	*16·9*	40,474	*18·36*	5·26
Germany	7,300	*16·1*	27,724	*12·58*	*3·80*
Holland	3,576	*7·9*	13,828	*6·27*	3·86
Belgium	319	*·7*	1,503	*·68*	4·71
France	705	*1·6*	3,576	*1·62*	5·07
Other countries . . .	659	*1·4*	3,207	*1·45*	4·86
Average Total .	45,381	*100·0*	220,414	*100·0*	4·85

World's production. The greater part of the world's output of mica is derived from India, Canada and the United States. In table 83 are shown the values of the mica raised during the past twenty years in those three countries. From this it will be seen that in the quinquennium 1899 to 1903, owing to increased output from Canada, the Indian contribution was only 60·1 per cent.; in the next quinquennium, 1904 to 1908, the Indian mica industry expanded enormously, but the proportion only increased to 61·8 per cent. owing to a great increase in the American production and an abnormally large production by Canada (£116,209) in 1906. During the third quinquennium, India's share increased to 69·7 per cent., while that of Canada decreased by 4½ and that of America by 2 per cent. In the period now under review India has more than maintained her place. The value of the mica raised has increased enormously. In India the value per cwt. has risen from £5·8 to £10·04, or to almost double. At the same time there has been a great rise in the cost of production due to conditions consequent on the war, increased cost of labour,

TABLE 83.—*Value of Mica raised in the three Principal Producing Countries during the twenty years 1899 to 1918.*

YEAR.	Canada.	India (a)	United States of America.	Total.	*India's per cent. of total.*
	£	£	£	£	
1899	32,600	73,372	25,576	131,548	*55·78*
1900	83,200	109,554	25,079	167,833	*65·28*
1901	32,000	70,034	23,716	125,750	*55·69*
1902	27,181	87,594	19,385	134,160	*65·29*
1903	35,571	86,297	28,626	150,494	*57·34*
TOTAL	**160,552**	**426,851**	**122,382**	**709,785**	...
Average	*32,110*	*85,370*	*24,477*	*141,957*	*60·14*
1904	30,584	97,932	24,063	152,579	*64·18*
1905	33,634	159,627	40,231	233,492	*68·37*
1906	116,209	254,999	54,998	426,206	*59·83*
1907	66,604	228,161	78,422	373,187	*61·11*
1908	38,320	126,834	53,585	218,739	*57·97*
TOTAL	**285,351**	**867,553**	**251,299**	**1,404,203**	...
Average	*57,070*	*173,511*	*50,260*	*280,841*	*61·78*
1909	30,345	154,978	57,603	242,926	*63·79*
1910	39,093	188,983	69,219	297,295	*63·56*
1911	26,422	207,778	73,060	307,260	*67·62*
1912	29,564	341,349	68,151	439,064	*77·74*
1913	34,931	302,564	89,540	427,035	*70·85*
TOTAL	**160,355**	**1,195,652**	**357,573**	**1,713,580**	...
Average	*32,071*	*239,130*	*71,515*	*342,716*	*69·77*
1914	22,410	191,066	67,801	281,277	*67·92*
1915	18,885	208,496	88,106	315,487	*66·08*
1916	25,180	341,255	122,139	488,574	*69·84*
1917	44,803	575,285	155,624	775,712	*74·16*
1918	55,147	598,971	157,185	811,303	*73·82*
TOTAL	**166,425**	**1,915,073**	**590,855**	**2,672,353**	...
Average	*33,285*	*383,015*	*118,171*	*534,471*	*71·66*

(*a*) Export values for official years.

tools and mining machinery. The summary of table 82 given in table 83 shows that during twenty years India has contributed more than three-fifths of the world's production, and Canada and the United States about one-fifth each.

There are several interesting points in the production from these three countries. Although the value of the mica raised in India is higher than in any other country, it is all in the form of block and splittings and it is all exported. In the United States, on the other hand, in addition to block or sheet mica, between three and four thousand tons of scrap mica are raised yearly and are used in the preparation of various mica products, mica powder, etc. No attempt has yet been made to utilise scrap mica in India. The Canadian product consists of phlogopite, while that from India and United States of America is mainly muscovite, and comes entirely from the provinces of Ontario and Quebec. The qualities of phlogopite make it of special value for certain electrical purposes for which the harder muscovite is not suited. It seems probable that Canadian mica will always find a market and it need not necessarily be a direct competitor of Indian mica, for which there are a number of uses.

TABLE 84.—*World's Production of Mica (summary of Table 83).*

PERIOD.	Canada.	India	United States.	Total.
	£	£	£	£
1899-1903	160,552	426,851	122,382	**709,785**
1904-1908	285,351	867,553	251,299	**1,404,203**
1909-1913	160,355	1,195,652	357,573	**1,713,580**
1914-1918	166,425	1,915,073	590,855	**2,672,353**
TOTAL .	**772,683**	**4,405,129**	**1,322,109**	**6,499,921**
Per cent. of total .	*11·89*	*67·77*	*20·34*	*100·00*

Increased use of mica.

It will be noticed that, commencing with 1905, there has been a great increase in the world's annual production of mica. This is due largely to the

invention of *micanite,* in which small and inexpensive sheets of mica are cemented together with shellac under pressure, with the production of large sheets costing much less than the natural sheets of equal size. The decreased cost of this material led to the increased application of mica in the arts, especially for electrical insulation. Furthermore, scrap mica, formerly thrown away, is now ground up and used for boiler and pipe lagging, as a lubricant, and for wall papers and paints.

Amongst the special uses in connection with the war may be mentioned the employment of mica sheets as compass cards for gyro-compasses on battleships and submarines. It had an extensive use in long distance telegraphy and telephony and in wireless installations. It was also used as washers for insulating the stays in all aircraft.

Possible competitors in the mica industry.

The urgent demand for mica for munitions purposes during the war led to the examination of suitable areas and in certain cases to active operations in areas which hitherto had not been producers. During the period under review mica mining and prospecting probably reached its zenith.

Of other areas known before the war as producers of mica the most important was German East Africa. In 1914 it was the fourth largest producer. The mica is supposed to be practically equal to that of the best Indian ruby. The mica-bearing pegmatites are known to occur over considerable areas and are similar in mode of occurrence to mica-bearing rocks in other parts of the world. The mica is of two colours, greenish-brown and ruby. It is obviously an area of possibilities and under favourable conditions may easily become a formidable rival. In the Union of South Africa, according to Dr. P. A. Wagner writing in the South African Journal of Technology (April, 1918), mica-bearing pegmatites have a wide extension and distinct possibilities. The most important is considered to be that of the Leydsdorp division of the Pietersburg district of the Transvaal. Here the mica belt is 50 miles long and 2 to 4 miles wide. The better qualities of the mica have been tested and are said to be equal to the best Indian. Mica-bearing pegmatites also occur in Little Namaqualand and in Southern Rhodesia. Little is known about them. Mica is known to occur in the Cameroons, and in a consular report for 1916 it was said that efforts would be made to re-open

some of the more promising mica mines in Nyasaland for munitions purposes.

In South America, Brazil has been a producer in a small way for some time and exported in the year 1916 (last available figures) over one thousand cwts. valued at eleven thousand pounds. The Argentine and Guatemala also report exports of small amounts, but in both the latter countries the mica deposits are said to be of great potential value.

It will be seen from the above that deposits of payable mica are of wide-spread occurrence and are by no means confined to the three principal producing countries. India has been and still is the largest producer of sheet mica, but this has been due to a great extent to the fact that the area over which mica deposits occur is enormous and to a plentiful supply of cheap labour. Many of the deposits have been rifled superficially and it is becoming more and more a question of deep mining to obtain mica, with consequent increase in the cost of production, while the cost of labour (at its best inefficient) is daily increasing. It seems possible, therefore, that there will be increasing competition from areas where the deposits are still practically untouched and where consequently the cost of production, other things being equal, will be less.

Distribution of mica-bearing pegmatites in India.

Mica-bearing pegmatites are known to occur over a wide area in India. There are two chief centres of mining activity, one in Bihar and Orissa, the other in the Nellore district of the Madras Presidency.

In Bihar the mica belt runs obliquely through the junctions of the Monghyr, Hazaribagh, and Gaya districts, from Jhaja Railway station on the East Indian Railway main line to Chauparan in the west, a distance of over 60 miles with a breadth of 12 to 14 miles. South of this is another small area west and south of Hazaribagh town. Small but apparently payable deposits have been discovered in the district of Sambalpur and in Angul and Dhenkanal in Orissa.

The Nellore mica belt occupies the eastern half of the Madras coastal belt between latitudes 14° and 15°, over a tract of country some 60 miles long and 8 to 10 miles broad. Mining is also carried on in a small way in the Salem district. Mica is, however, known

to occur over a much wider area in the Presidency, *e.g.*, in S. E. Wainad and Coorg.

In Rajputana mica-bearing pegmatites have been worked in Ajmer-Merwara. Some mining is done in the State of Udaipur and in small areas which belong to the Gwalior State.

At all the above localities muscovite mica is mined. The variety known as phlogopite occurs in several places but is mined only in the Travancore State.

Geological occurrence.

The Bihar mica belt coincides with a great area of schists and associated gneissose granites. The belt is irregularly scarped and falls by a series of ghats from the Hazaribagh plateau to the Gangetic plain. Denudation has contributed to the irregularities of the surface and has opened up the country in such a manner as to facilitate prospecting for, and mining of, mica.

The schists are of great variety and are metamorphosed rocks of diverse origins, some sedimentary, others igneous. The foliation planes of the schists and gneisses are generally in conformity and the whole structure suggests that the two have been folded up together, the present appearance being due to denudation. The gneissose granite, or "dome gneiss" as it is often called from its characteristic mode of weathering, is composed of quartz and microcline with biotite and hornblende and accessory sphene, zircon and apatite. Pegmatites have been found in every class of rock and at all angles but generally with a strike parallel in direction to that of the foliation planes. The larger pegmatites tend to be finer in grain than those of more restricted occurrence. Not all are of the same value and some contain no payable mica. Experience has conclusivly shown that the more micaceous schists are the more favourable parent. The great development of pegmatites in areas close to spreads of the gneiss has suggested a genetic relation between the two.

In the Nellore district mica-bearing pegmatites are restricted in their distribution to the eastern half of the coastal plain and, although the whole is composed of one series of schistose rocks, there is no structural or petrological difference to account for this restricted distribution. The rocks are in general hornblende and biotite schists with subsidiary quartz ridges. The series in the

mass is very uniform but in its intimate geology there is great variety. The country being almost uniformly flat, outcrops are generally poor and prospecting difficult. The pegmatites occur parallel to the foliation of the enclosing rocks and no exception has been noticed. In contradistinction to Bihar the larger masses are coarser in structure than the smaller pegmatites. There is not the same association with gneissose granites as in Bihar.

The other mica-bearing pegmatites in India are found similarly in rocks of a schistose character.

Lithology and general characters of the pegmatites.

Pegmatites are generally looked upon as the end products of a granitic magma and, as the crystallisation took place under conditions of perfect quiescence and molecular mobility, the constituent minerals, quartz, felspar and mica have often segregated into large and comparatively pure masses. Many show a zoned structure the central mass being composed of granular quartz. This quartz core is regular in the pegmatites of Bihar and Rajputana, irregular in the Nellore district, or consistently on one wall as in Wainad. The common felspar is microcline and with quartz it often forms a graphic intergrowth which in parts of the Nellore belt takes the place of the central quartz core. Such an intergrowth is looked upon as a bad indicator for mica. The mica, often in "books" of large size, is muscovite of varying colours. In general it shows a tendency to be better developed near the contact of the pegmatite with the country rock. Sometimes it is found near both contacts or it may be at the junction of the quartz core and the felspathic margin. In those pegmatites of decidedly lenticular form the mica is often irregular in its distribution, occurring on the bulge only or at one end or the other.

The form of the pegmatites varies between wide limits. Some are regular sheets of long strike and restricted breadth. Many are lenticular, some elongated, others stout and short. There are also large and irregular masses. The size varies from the thinnest stringer an inch or so in breadth to masses of 50 yards or more in width.

The defects from which mica suffers are many. Most of the minerals of the pegmatite occur as inclusions. Oxides of iron are particularly common, either as scattered black spots or regularly

arranged in triple sets of feathery skeleton crystals cutting each other at angles of 60°, 90°, and 120°. Movement along gliding planes parallel to the principal rays of the natural pressure figure has caused the distortion of most crystals. Associated with these are ridging and cross graining. Marginal cracks and hair cracks also occur.

The colour of mica is variable. In Nellore it is generally some tinge of green, rarely brown or silvery white. Ruby mica is found throughout the Bihar belt, but green, brown, white and variegated micas also occur. In Sambalpur a pink mica has been found.

Most pegmatites contain, in addition to the main constituents, accessory minerals of which the commonest are tourmaline, garnet, apatite and beryl. The so-called rare earth minerals are also to be found and include amongst many others pitchblende, monazite, samarskite, and columbite.

Mining methods.

The exploitation of those pegmatites containing mica in payable proportions has been carried on as a serious business for less than fifty years, although for many years previously in both the principal mining centres mica was extracted for purely local use. The general mining practice differs in the two chief centres.

In Bihar the majority of the workings are still carried on in the primitive style of sinking a narrow winding hole from "book" to "book" of mica, while the mica, waste rock, and water are all raised to the surface by hand. The important factors of dip and strike are not recognised and there is no attempt at development or the investigation of the possibilities of the deposit as a whole. Such work does not materially differ from that of the aboriginal miners.

Although the above represents very briefly the custom of the majority, there are exceptions where the underground work is properly carried out under skilled direction. The mines are equipped to deal with waste rock and water, while the extraction of mica is done in the most suitable manner. Mine plans and sections are kept up-to-date. The work so done has successfully laid some of the ghosts which have haunted mica mining. The intro-

duction of compressed air drills has proved of great value not only in increased speed of development work but has also shown that the light power drill is not beyond the compass of the coolie and that with it no more mica is spoilt (probably not so much) than under the old method. Overhand stoping has been successfully carried out in several mines where conditions were suitable. But the greatest advance of all was made by the late Mr. H. J. Sparks, of Messrs. F. F. Chrestien and Co., who has shown that there is repetition of the lenticular form of pegmatite at depth.

The generally flat ground surface in the Nellore district was probably the deciding factor in the prevalent custom of open-casting all deposits. The depth to which such can be worked successfully is limited by the stability of the walls of the quarry, the accumulation of large heaps of waste in the immediate vicinity of the workings, the value of the pegmatite, and the depth of the water-level. It is impossible by such means to do deep mining and the deepest excavation known in the district is about 180 feet. The method is wasteful in that, the whole of the pegmatite, including the barren portions, is handled, the dump is put on the lip of the hole and has to be re-handled for extension, and the latter affords easy access to all surface water and after rain the pit requires cleaning before work can be resumed. The continuance of this method is largely due to the complete lack of mining knowledge amongst the supervising staffs.

As in Bihar some of the mines (those which have recently come under European supervision) are being worked on modern lines by means of inclines and vertical shafts, with equipment for dealing with waste rock and water. Compressed-air drills have also been installed on some of the mines.

Labour statistics.

Many of the mica mines are under the control of the Indian Mines Act of 1901, and the labour statistics for the period under review, given in table 85, afford a fair index of the activity of the industry. The average number of persons employed during the quinquennium was 17,614, an increase of over 2,600 above that of the preceding period. The increase was entirely due to activity in the Bihar field. The risks attending mica mining seem to be much less than those of coal mining in India,

TABLE 85.—*Labour Statistics of Mica Mines for the years 1914 to 1918.*

PROVINCE.	1914.	1915.	1916.	1917.	1918.	*Average*
NUMBER OF PERSONS EMPLOYED—						
Bihar and Orissa . .	11,384	7,595	11,930	16,202	21,364	13,695
Madras	5,269	798	4,254	3,892	3,763	3,595
Rajputana . . .	332	129	307	385	465	324
TOTAL .	**16,985**	**8,522**	**16,491**	**20,479**	**25,592**	**17,614**
NUMBER OF DEATHS FROM ACCIDENTS IN MICA MINES—						
Bihar and Orissa . .	9	5	2	3	2	*4·2*
Madras	...	1	...	2	...	*·6*
Rajputana . . .	1	1	...	...	1	*·6*
TOTAL .	**10**	**7**	**2**	**5**	**3**	**5·4**
DEATH RATE PER 1,000 PERSONS EMPLOYED AT MICA MINES—						
Bihar and Orissa . .	0·79	0·65	0·16	0·18	0·09	*0·37*
Madras	...	1·25	...	0·51	...	*0·35*
Rajputana . . .	3·01	7·75	...	...	2·15	*2·58*
Average .	*0·58*	*0·82*	*0·12*	*0·24*	*0·11*	*0·30*

Monazite.

[G. H. Tipper.]

Monazite, a phosphate of the rare earths of the cerium group, owes its economic value to the fact that it contains a small and variable percentage of thorium oxide. The latter constitutes the raw material for the preparation of thorium nitrate, used in the manufacture of incandescent mantles. The cerium salts obtained during the extraction are now being employed in the preparation of pyrophoric alloys ('misch metal'). An interesting minor use is in the manufacture of special optical glasses.

Output and Value.

The output and value for the past five years are shown in the following table :—

Year.	Quantity.	*Value.*
	Tons.	£
1914	1,185·65	*41,411*
1915	1,107·7	*32,238*
1916	1,292·3	*37,711*
1917	1,940·3	*56,489*
1918	2,117·2	*58,819*

Before the discovery of monazite sands on the coasts of Travancore the world's supply was obtained from sands of similar character in Brazil. In 1915 the last year for which figures are available, the Brazilian output amounted to only 484 short tons and has probably still further decreased.

The monazite is supposed to be mainly derived from the gneisses of the Travancore hills but is only known with certainty to occur in pegmatite intrusions. The mineral forms one of the constituents of the sands along the sea-shore. In certain places selective action by the waves on these sands has led to the local concentration of large quantities of monazite; the sand is again further concentrated by mechanical means.[1]

[1] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XLIV, p. 186 (1914).

Work was commenced in 1911 by the London Cosmopolitan Mining Company. This was replaced by the Travancore Minerals Company, who have been purged of their German interests. Thorium Limited also hold a concession. The whole output now goes to the United Kingdom.

Monazite also occurs in the sands to the east of Cape Comorin, in the Tinnevelly district, and again near Waltair in Vizagapatam.

A crystalline variety containing only 2¼ per cent. of thorium oxide has been found in pegmatites of the Bangalore district, Mysore State.[1]

More recently a large number of beautiful crystals of this mineral have been found with pitchblende and columbite in a pegmatite in the Gaya district, Bihar and Orissa Province.[2]

It has been found in minute quantities in concentrates from Tavoy and Mergui.[3]

Petroleum.

[E. H. PASCOE.]

Total production.

During the previous period reviewed the production of petroleum increased from 233½ million gallons in 1909 to 277½ million gallons in 1913. During the past quinquennium there was a decrease in 1914 balanced by an increase in 1916, the latter year being responsible for a record production of 297 million gallons; the other three years gave equable figures approximating the average for the five years, which works out at 282½ millions. The total increase of 212 million gallons over the production of the period 1909-1913, shown in table 86, was due principally to the Yenangyaung field, where productive sands at 3,000 feet depth are now being exploited, and to a small extent to Assam and the Punjab.

Position of India amongst oil-producing countries.

India still occupies a comparatively low place among the oil-producing countries, and in 1917 turned out only 1·59 per cent. of the world's total supply. It will be seen from table 87 that, owing to the effect of the war upon Roumania, India now takes the fifth place among the chief oil-producing

[1] Mineral Resources of the Mysore State, p. 191.
[2] G. H. Tipper, *Rec. Geol. Surv. Ind.*, L, p. 255 (1919).
[3] A. M. Heron, *Rec. Geol. Surv. Ind.*, XLVIII, p. 179 (1917).

TABLE 86.—*Production of Petroleum in India during the years 1914 to 1918.*

Year.	Quantity. Gallons.	Quantity. Metric tons. (a)	Value.
			£
1914	259,342,710	*1,041,537*	958,565
1915	287,093,576	*1,152,986*	1,065,182
1916	297,189,787	*1,193,533*	1,119,405
1917	282,759,523	*1,135,580*	1,092,965
1918	286,585,011	*1,150,944*	1,131,904
Average .	*282,594,121*	*1,134,916*	*1,073,604*

(*a*) The metric ton is assumed to be equivalent to 249 Imperial gallons of crude petroleum, most of which has an average specific gravity of about 0·885.

TABLE 87.—*World's Production of Petroleum in 1913 and 1917.*

Countries.	1913. Metric Tons.	1913. *Per cent. of total.*	1917. Metric Tons.	1917. *Per cent. of total.*
United States	34,841,839	*64·53*	47,132,673	*66·17*
Russia	8,832,139	*16·36*	9,698,795	*13·62*
Mexico	3,640,905	*6·74*	7,772,076	*10·91*
Sumatra, Java, Borneo . .	1,682,088	*3·11*	1,817,323	*2·55*
India	1,114,679	*2·07*	1,135,580	*1·59*
Galicia	1,098,934	*2·04*	838,517	*1·18*
Japan	272,973	*·51*	407,441	*·57*
Roumania	1,905,288	*3·53*	376,970	*·53*
Peru	299,856	*·56*	356,103	*·50*
Trinidad	70,789	*·13*	224,823	*·32*
Egypt	13,302	*·02*	141,792	*·20*
Germany	139,967	*·26*	140,562	*·20*
Canada	32,059	*·06*	28,862	*·04*
Italy	6,642	*·01*	7,075	*·01*
Other Countries	37,952	*·07*	1,145,541	*1·61*
TOTAL .	**53,989,412**	*100·00*	**71,224,133**	*100·00*

countries, though how long she will maintain it is doubtful. America has made another big stride and now contributes two-thirds of the world's supply.

Imports of kerosene.

Foreign mineral oil has to some extent been displaced by the domestic products, but consumption is still on the increase in India, and there persists a large market in India and Burma for foreign oil, which has to pay an import duty of 1½ annas per gallon. The average annual imports of foreign mineral oils during the period 1908-1909 to 1912-1913 amounted to about 89⅓ million gallons, valued at nearly 2½ millions sterling, while for the five financial years 1913-1914 to 1917-1918 the average annual import shows a small increase of about 400,000 gallons, the total average value being about 2¾ million pounds (see table 88). The largest import occurred in 1914-15, when over 106¾ million gallons of foreign oil came into India, while the lowest figure, 62¾ million gallons, was reached in 1917-18. The chief feature of the period under review is the domination by America of the imports. In the preceding quinquennial period America's share of the imports rose at one time to 64·5 per cent. and averaged 53·2 per cent.; throughout the period under consideration an average of 54·8 per cent. was with little variation maintained. Russia's average contribution fell from 1·1 per cent. to zero, its place being almost entirely filled by Borneo with an average share of 23·3 per cent. The remaining imports, ascribed to other countries, amount to 21·5 per cent. of the total; amongst these it is worthy of notice that imports from Sumatra have fallen from 6·1 per cent. yearly average in the preceding quinquennium to 1·4 per cent. in 1913-14 to 1917-18, while the supply from Persia increased from ·27 to 9·2 per cent. There is every likelihood that both Persia and Mesopotamia will take an important place amongst the oil-producing countries of the world.

Value of Imports.

The values of the imported mineral oil during the period under review are shown in table 89; the average annual value was Rs. 4,12,34,850 as compared with an average of Rs. 3,67,79,808 for the previous period.

Exports.

The annual exports of oil and of paraffin wax have been practically doubled (see table 90).

TABLE 88.—*Origin of Foreign Mineral Oil imported into India during the years 1913-14 to 1917-18.*

COUNTRIES.	1913-14.		1914-15.		1915-16.		1916-17.		1917-18.		*Average.*	
	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*	Gallons.	*Per cent. of total.*
Russia	1,079,209	*1·1*	582,661	*·5*	..	..	..	..	..	..	(*a*)332,374	*·4*
Borneo	24,671,475	*26*	25,103,437	*23·5*	26,319,545	*27·4*	19,205,063	*21·8*	9,142,834	*14·6*	20,888,471	*23·3*
United States	51,671,687	*54·4*	55,689,865	*52·2*	52,439,556	*54·6*	51,856,617	*58·8*	34,371,245	*54·7*	49,205,794	*54·8*
Other Countries	17,600,702	*18·5*	25,403,669	*23·8*	17,223,759	*18*	17,093,842	*19·4*	19,282,730	*30·7*	19,320,940	*21·5*
TOTAL	95,023,073	*100·0*	106,779,632	*100·0*	95,982,860	*100·0*	88,155,522	*100·0*	62,796,809	*100·0*	89,747,579	*100·0*
	£		£		£		£		£		£	
Value	2,743,764		2,938,027		2,676,490		2,959,541		2,427,128		2,748,990	

(*a*) Average of 5 years.

TABLE 89.—*Annual value of Mineral Oil imported during the years 1913-14 to 1917-18.*

COUNTRIES.	1913-14.	1914-15.	1915-16.	1916-17.	1917-18.	Average.	*Average value per gallon.*
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.	As.
Russia	3,81,810	2,73,120	...	...	...	(*a*)1,30,986	*6·30*
Borneo	89,65,725	91,38,120	90,51,045	59,63,235	29,87,310	72,21,087	*5·53*
United States	2,31,01,830	2,47,05,330	2,50,44,975	3,11,00,670	2,43,09,840	2,56,52,529	*8·34*
Other Countries	87,07,095	99,53,835	60,51,330	73,29,210	91,09,770	82,30,248	*6·81*
TOTAL .	**4,11,56,460**	**4,40,70,405**	**4,01,47,350**	**4,43,93,115**	**3,64,06,920**	**4,12,34,850**	*7·35*

(*a*) Average of five years.

TABLE 90.—*Exports of Mineral Oil and Paraffin Wax during the years 1914 to 1918.*

YEAR.	Mineral oil.	Paraffin wax.
	Gallons.	Cwts.
1914	24,445,573	362,676
1915	27,375,257	384,301
1916	25,457,423	424,318
1917	21,620,451	438,888
1918	23,395,882	508,964
Average .	*24,458,917*	*423,829*

Occurrence of Indian petroleum.

The petroleum resources of India are confined to the two systems of folded rocks at either end of the Himalaya and are :—

(1) The Iranian system on the west, including the Punjab and Baluchistan and continued beyond British limits to Persia and Mesopotamia, where the oilfields have attracted interest for many years.

(2) The Arakan or Shan system on the east, including Assam and Burma, with their southern geotectonic extension to the highly productive oilfields of Sumatra, Java and Borneo.

In both areas the oil is associated with Tertiary strata, and has had probably similar conditions of origin in both cases. In Burma it is known to occur in beds of Nummulitic age, but by far the greater number of seepages and all the fields of importance are in the next highest geological series, to which there is every reason to suppose the oil is indigenous. In Assam oil is found in a similar series. In the Punjab on the other hand it is the Nummulitic which is the predominant oil-yielding series, and although the only supplies which have so far proved of economic importance are found in the series above, there is good reason to suppose that the oil has migrated up from the Nummulitic below. Whether in Burma, Assam or North-West India, the occurrences of petroleum are always con-

nected with an anticlinal structure. In the Yenangyaung field, the best known field of Burma, conditions have been ideal. It lies on a N.N.W.-S.S.E. flat anticline, the axis of which by variation in pitch has produced a flat dome in the Kodaung tract. The rocks in this dome include several porous sands at various depths, each covered by an impervious clay-bed, which has helped to retain the oil until the impervious layers are pierced by artificial wells. A similar area, with a structure as favourable, is now being exploited at Khaur in the North Punjab. In many parts of the Punjab, however, and in the Baluchistan area the rock-folds have been too deeply truncated by agents of denudation or have been dislocated by earth-movements, and much of the original stores of oil have disappeared; oil-springs are common enough, but most of them seem to be mere "shows" not connected with reservoirs that can be tapped by artificial means.

The provincial production of petroleum in India is shown in table 91.

Table 91.—*Provincial Production of Petroleum during the years 1914 to 1918.*

Province.	1914.	1915.	1916.	1917.	1918.
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Burma . .	254,652,963	282,291,932	291,769,083	272,795,191	274,834,556
Assam . .	4,688,547	4,550,150	5,236,890	9,344,815	10,999,648
Punjab . .	1,200	251,494	183,814	619,517	750,807
TOTAL, Gallons	**259,342,710**	**287,093,576**	**297,189,787**	**282,759,523**	**286,585,011**
Total, Metric Tons. (*a*)	*1,041,537*	*1,152,986*	*1,193,533*	*1,135,580*	*1,150,944*

(*a*) The metric ton is assumed to be equivalent to 249 gallons of crude petroleum.

Punjab and Baluchistan.

In the Punjab, oil-springs have been known for many years to exist in the Rawalpindi district and further to the south-west, but the total output of the province up to 1915 has been negligible; from that year onwards, however, owing to the development of the

Khaur field, the figure, though small, has begun to assume serious proportions, and will almost certainly expand much more in the near future; in 1918 it rose to over ¾ million gallons. For an account of the occurrence of oil in Baluchistan, reference should be made to the Quinquennial Review for the years 1898-1903 (*Records*, Vol. XXXII, p. 74).

Assam.

Oil-springs are known in various parts of Assam, the most prominent being those appearing in the coal-bearing series in North-East Assam, especially in the Lakhimpur district,[1] and those at the southern foot of the Khasi and Jaintia Hills. Marketable oil comes from the Lakhimpur district, where systematic drilling has been conducted at Digboi during the past twenty years by the Assam Oil Company, Limited. The output of the Digboi area, although it has shown a marked increase during the five years under review and in 1918 was three times what it was in 1911, is still very small. The new Badarpur field in Kachar contributed nearly three million gallons in 1917 and over 5½ million gallons in 1918; from recent results there seems every likelihood of this production being more than maintained.

The principal products marketed from the Digboi area are petrol, jute-batching oil, lubricating oils, paraffin wax and a comparatively low grade of kerosene suitable for bazar consumption. The wax, sold as such or in the form of candles, appears to be of excellent quality with a melting point of 135°F. and over.

Table 92 shows the amounts of the various products turned out during the past five years.

TABLE 92.—*Output of the Digboi Oil Refineries in the years 1914 to 1918.*

	1914.	1915.	1916.	1917.	1918.
Kerosene (*a*)	2,573,653	2,287,502	2,692,052	3,244,124	2,940,128
Batching and Lubricating oil. (*a*)	435,267	532,994	625,754	468,777	747,027
Petrol (*a*)	217,863	240,213	366,675	461,945	448,735
Wax and Candles (*b*) . .	1,980,320	3,279,244	2,375,266	1,968,079	2,738,266
Sundry oils (*a*) . . .	402,223	343,953	362,741	549,168	465,556

(*a*) Imperial gallons.
(*b*) lbs.

[1] E. H. Pascoe: The Petroleum Occurrences of Assam, *Mem. Geol. Surv Ind.*, XL, pt. 2 (1914).

The average number of persons employed daily on the Digboi area during the period under review was 561.

Burma.

The most productive oilfields of Burma are those on the eastern side of the Arakan Yoma in the Irrawadi valley forming a belt stretching from below the Magwe district, in which the well-known field of Yenangyaung occurs, through Myingyan which contains Singu, across the Irrawadi into Pakokku, where Yenangyat is situated, and up into the Chindwin district. It has been shown that this belt coincides with the site of a gulf which existed in the Pegu epoch (approximately Oligocene and Miocene), and which gave place to a river, the forerunner of the present Irrawadi.[1] The production of the Burmese oilfields for the years 1914 to 1918 is shown in table 93.

Yenangyaung.

Yenangyaung, the oldest and best known of the fields, still holds an easy lead as a producer. Of the total 1½ square miles of petroliferous territory, all that outside the two native 'reserves' of Twingon and Beme is held under lease by the Burma Oil Company, the pioneers of this field. It is within the two small reserved tracts covering jointly some 450 acres, and especially within the Twingon Reserve, that competition has been so keen as to threaten injury to the oil-sands by water liberated from water-sands, and danger of fire in the midst of a congested forest of greasy wooden derricks covering highly productive flowing wells emitting immense quantities of inflammable gas. The appointment of a Warden, who is assisted by an Advisory Board composed of representatives of the companies engaged in exploiting the field, resulted in systematic measures for the protection of the sands, and will undoubtedly do much to prolong the life of the field. Fears have been expressed that excessive exploitation was leading to premature exhaustion; but although the yield from the upper sands is now very small, lower horizons still continue to be tapped by deep wells, which now reach depths of 3,000 feet, and a fairly steady output in the neighbourhood of 200 million gallons per annum is maintained. Wells tapping the deepest sands show a tendency towards a swifter decline in yields; this is perhaps due to the natural shrinking and tightening of the anticline area as deeper and deeper horizons are reached. The total depth to which the petroliferous horizons extend is still an unanswered question.

[1] E. H. Pascoe: The Oil-fields of Burma, *Mem. Geol. Surv. Ind.*, XL, p. 251.

Yenangyat.

The output of the Yenangyat field, which was never a very rich one, showed a serious decline between 1905 and 1910. During the five years 1909-1913, the average annual production amounted to little more than 5 million gallons; this average has been maintained during the period under review.

Singu.

Although inferior to Yenangyaung, Singu is a promising field, and has in the past been treated as a reserve by the Burma Oil Company from which to make good any decline in other areas. It is now being steadily and scientifically developed, the annual average production showing an increase of over 50 per cent. in comparison with the preceding quinquennium.

Minbu.

In the year 1910 Minbu began to produce for the first time. In 1918 the production rose to 4·8 million gallons, but the average during the past five years is under 2·9 million gallons.

Chindwin.

The Chindwin field under the Indo-Burma Petroleum Company began to produce in 1918, yielding nearly half a million gallons. In spite of a very great deal of laborious prospecting, this is the only additional area in Burma to those described in 1912 in the Geological Survey Memoir, which has ever got beyond the testing stage, but time alone will show whether it will make any serious difference to the oil supply of Burma. Yenangyaung, Singu, Yenangyat and Minbu are the four areas which alone have so far proved of real economic importance. Some areas, however, are undergoing retesting, including the interesting little dome at Ondwe,[1] where a considerable amount of gas has recently been struck.

Arakan Coast.

Besides the Upper Burma oilfields, the islands off the Arakan coast, noted for their mud volcanoes, have also been known for many years to contain oil deposits of uncertain value. The chief operations have been carried on in the Eastern Baronga Island near Akyab and on Ramri Islands in the Kyaukphyu district. Folding and denudation in these regions have been too severe to warrant the expectation of oil in much quantity. The output from the Kyaukphyu wells recovered a little during the past five years, but this is more than balanced by a continued decline in the Akyab area.

[1] *Mem. Geol. Surv. Ind.*, XL, p. 138.

TABLE 93.—*Production of the Burma Oil-fields during the years 1914 to 1918.*

OIL-FIELD OR DISTRICT.	1914.	1915.	1916.	1917.	1918.	*Average.*
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	*Gallons.*
Akyab . .	12,948	12,045	11,882	10,894	10,821	*11,718*
Kyaukphyu .	25,987	23,220	68,843	46,821	46,598	*42,294*
Yenangyaung .	174,981,799	198,809,315	199,152,938	176,979,020	203,638,043	*190,712,223*
Singu . .	73,409,518	77,005,880	85,146,138	85,639,166	61,035,972	*76,447,335*
Yenangyat .	4,516,685	4,099,345	5,310,740	6,620,908	4,739,587	*5,057,453*
Minbu . .	1,683,190	2,316,207	2,043,542	3,468,382	4,826,735	*2,867,611*
Thayetmyo .	22,836	25,920	35,000	30,000	63,000	*35,351*
Upper Chindwin	..	..	..	..	473,800	..
TOTAL, Gallons	254,652,963	282,291,932	291,769,083	272,795,191	274,834,556	*275,268,745*
Total, Metric Tons	*1,022,702*	*1,133,702*	*1,171,763*	*1,095,563*	*1,103,753*	*1,105,497*

Ruby, Sapphire, and Spinel.

[E. H. PASCOE.]

Production.

During the period covered by this review, the whole of the output of ruby, sapphire and spinel in the Indian Empire was derived from Upper Burma. Table 94 shows the annual output figures for Burma during the period under review, the average annual value being £41,817.

TABLE 94.—*Production of Ruby, Sapphire and Spinel in Burma during the period 1914 to 1918.*

YEAR.	Quantity.	*Value.*
	Carats.	£
1914	304,872	*43,133*
1915	251,449	*36,298*
1916	209,724	*37,513*
1917	198,200	*51,831*
1918	164,115	*40,310*
Average .	*225,672*	*41,817*

Burma.

The prosperous condition noticed in the previous reviews of the ruby mining industry as conducted by the Burma Ruby Mines, Limited, in the Mogôk area, continued until towards the end of 1907, when the demand for rubies suddenly fell away and prices declined, owing to the world-wide commercial depression that then set in. The slump has continued in subsequent years and the value of the production, of which the annual average was over £84,000 during the period 1904-08, fell to £63,272 between 1909-13 and has fallen still lower during the period under review to £41,817. The rubies are derived from crystalline limestones which stretch westwards from Mogôk as far as the Irrawadi, but the Company obtain all their output from the alluvial detritus of the Mogôk valley. At the mouth of the valley a waterfall supplies electric power.

The Burma Ruby Mines, Limited, was granted a new lease for 28 years with effect from the 30th April 1904, for the collection of precious stones in the townships of Mogôk, Kyatpyin and Katha in the Ruby Mines district. The Company was required by the lease to pay an annual rent of Rs. 2,00,000 (£13,333), *plus* 30 per cent. of the net profits made each year, this being a continuance of the arrangement previously in force. In consequence of the slump, however, the Company was unable to pay dividends for the years 1908-10, but matters improved slightly during 1911 and a dividend at the rate of 4⅙ per cent. was paid for the year ending February 29th, 1912, and a similar dividend for the year ending February 28th, 1913. The year 1913 was a bad one and resulted in a deficit of over £9,000 for the twelve months ending February 28th, 1914. Owing to this succession of poor years, the Company was compelled to approach the Burma Government with a view to the remission of arrears of rent and other charges. These amounted in 1909 to nearly £24,000; the Government agreed to the postponement of payment of this sum and arranged that the Company should make over the royalties collected from the local native ruby-miners less a fee of 10 per cent. on account of charges for collecting. In 1911, the Company proceeded to develop new ground in the neighbouring valleys of Kathé and Bernardmyo and on the understanding that £20,000 would be spent on such development, the Government agreed, with the sanction of the Secretary of State, to remit the Company's debts on account of arrears until such time as the profit should exceed 10 per cent. on the present paid-up

capital. At the end of 1913, the proceeds of local sales fell off to such an extent that further concessions by the Government were found necessary early in 1914.

Labour. The following are the labour statistics for the ruby mines under the Mines Act:—

YEAR.	Average number of persons employed daily.
1914	1,729
1915	972
1916	1,202
1917	1,245
1918	1,300

The number of deaths during the period was 2, giving an average death-rate of 0·31 per 1,000. In addition large numbers of persons are engaged in working on their own account under licenses issued by the Burma Ruby Mines, Limited.

Rubies are known to occur at Naniazeik in the Myitkyina district near the jadeite tract;[1] but no output has been reported for the period under review. Ruby-bearing ground was also discovered during the year 1913 in Momeik State and royalties amounting to Rs. 1,740 were collected by the Local Government from the native miners. Sapphires are found accompanying the rubies in the Ruby Mines of Upper Burma and are undoubtedly of the same origin.

Kashmir. The sapphires of Kashmir seem to have been first discovered in 1881 or early in 1882, when a landslip disclosed the sapphire-bearing rocks. These were found to be intrusive pegmatites containing tourmaline, garnet, kyanite and euclase in addition to the sapphires. The actual locality is a valley near Sumjam in Padar, Zanskar, at an elevation of about 14,000 feet; here the gem has been found both *in situ* in a felspathic igneous rock in a cliff 1,600 feet above the valley, and in the débris in the valley itself. For some years the Kashmir Darbar derived a considerable revenue from the sapphire mines, which were then left unworked for some years on the supposition that they had

[1] *Rec. Geol. Surv. Ind.*, XXXVI, p. 164 (1907).

become exhausted. In 1906 the Kashmir Mineral Company, Limited, started work under license from the Darbar, and obtained a considerable return of valuable stones. One stone obtained in 1907 was sold for £2,000. Subsequent results, however, were discouraging and no serious work has been done during the past ten years. Owing to the high altitude of the sapphire locality, the ground is under snow and inaccessible for the greater part of the year, work being possible only during the months of July, August and September.

Salt.

[E. H. Pascoe.]

Production.

The average annual production of salt in India during the five years 1914 to 1918 was 1,395,102 statute tons (see table 95), exclusive of that manufactured at Aden, which averaged 178,221 tons per annum during the same period. Throughout the period under review, production and imports fluctuated, but there was a marked rise in the former during the last of the five years. The average annual production shows a substantial rise of over 93,000 statute tons. The salt manufactured in the country and imported by sea amounted annually to over 1¾ million tons. The consumption thus amounted to about 13½ lbs. per head of the population. The duty of 1 rupee a maund remained in force up to the 1st March 1916, from which date it was raised to 1 rupee 4 annas.

Table 95.—*Production of Salt in India (excluding Aden).*

Year.	Statute Tons.	Metric Tons.
1914	1,203,762	1,223,022·1
1915	1,393,289·7	1,415,582·6
1916	1,359,164·4	1,380,910·6
1917	1,304,673·6	1,325,548·7
1918	1,714,621·7	1,742,069·1
Average	*1,395,102·[illegible]*	*1,417,426·8*

Sources of Indian Salt.

The salt produced in India is obtained from three principal sources, *viz.*, from sea-water, from subsoil water and lakes in areas of internal drainage, and from

rock-salt beds. By far the largest amount—about 60 per cent.—is derived from the first source, chiefly in Bombay and Madras, while the rock-salt beds of the Salt Range, of Kohat and of Mandi State provide about one-tenth of the Indian output.

Provincial production. Table 96 shows the provincial production for the five years 1914 to 1918.

TABLE 96.—*Provincial Production of Salt during the years 1914 to 1918.*

PROVINCE.	1914.	1915.	1916.	1917.	1918.	*Average.*
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	*Statute Tons.*
Aden	144,463	352,232	120,406	122,926	142,075	*178,221*
Bengal	6	(a)	2	21	30	*12*
Bombay and Sind	486,898	524,257	484,742	457,989	481,808	*487,139*
Burma	21,522	28,521	38,774	43,650	62,828	*39,059*
Central India	..	..	6·7	25·1	5·3	*7*
Gwalior State (a)	99	127	114	269	312	*184*
Kashmir	73	36·7	36·7	..	..	*29*
Madras	298,862	345,714	481,091	396,913	596,671	*423,850*
Northern India (including Rajputana).	396,302	494,634	354,398	405,731	572,668	*444,747*
Rajputana (Indian States).	..	..	..	75·5	299·4	*75(b)*
TOTAL Statute Tons.	1,348,225	1,745,521·7	1,488,570·4	1,427,599·6	1,856,693·7	1,573,323
Total Metric Tons	*1,369,796·6*	*1,773,450*	*1,512,387·5*	*1,450,441·1*	*1,886,405*	*1,598,496*

(*a*) Relate to official years.
(*b*) Average of 5 years.

The returns for provincial production show a marked increase in the amount of salt manufactured at Aden, from 110,373 tons, the average for the years 1909 to 1913, to 178,221 tons a year in the quinquennial period 1914-18. There was also an increase in Bombay from an average of 481,879 tons to 487,139 tons per annum; in Madras from 404,280 to 423,850 tons; in the North Indian lakes and mines from 388,431 to 444,747 tons per annum. The production in Burma rose to nearly 63,000 tons in 1918. The small quantities manufactured in Gwalior and that separated in the manufacture of saltpetre in Bengal are unimportant. The average annual total of salt production has thus risen from 1,412,274 tons for 1909-13 to 1,573,323 tons for 1914-18.

Bombay, as before, is the chief producer, most of the salt being obtained from sea-water, supplemented by the use of sub-soil brine on the border of the Rann of Cutch in an area where, possibly, the

brines are directly derived from sea-water. In the Madras Presidency, small quantities of salt are collected in the Masulipatam area, but the rest is manufactured from sea-water. In Upper Burma, salt is obtained from sub-soil brines in the districts of Sagaing, Shwebo, Myingyan, Yamethin, Lower Chindwin, Minbu, Meiktila, and the Hsipaw State. It is often difficult in some of the districts in the "dry zone" of Upper Burma to obtain deep well water that is not noticeably saline.

Brine wells of Bawgyo.

A special account of the brine wells being worked near Bawgyo in the Hsipaw State has been published by Mr. T. D. LaTouche.[1] The only well being worked at the time was 45 feet deep, and the crude brine included 25·58 per cent. of dissolved salts, which were composed of about 60 per cent. of sodium chloride, 36 per cent. of the sulphate, with small quantities of other salts.

Sub-soil and lake-brine.

The most important of the areas worked for sub-soil and lake brine is the desert region of Rajputana, from which about 250,000 tons of salt are manufactured every year. The whole country is impregnated with salt from the Coast of Cutch and Sind north and north-eastwards to the borders of Delhi district and Bahawalpur State. In many areas of internal drainage there are small temporary salt-lakes which are utilised, as at Sambhar and Didwana; while in other places sub-soil brine is raised, as at Pachbadra. Most of the salt in this region appears to be brought in as fine dust by the strong winds which blow from the south-west and south-south-west during the hot weather. These winds blow across the salt-incrusted Rann of Cutch, and carry away the finely-powdered salt in large quantities into the heart of Rajputana, where it becomes fixed when the following monsoon brings rain enough to wash the salt into the small lakes in areas of internal drainage.[2]

Sambhar Lake.

Sambhar, the largest of the Rajputana salt-lakes, covers an area of 60-70 square miles during the monsoon, but dwindles, generally, to a small central puddle by the following March or April. It has been shown by careful sampling at regular intervals that the mud forming the bed of the lake contains on an average 5·21 per cent. of sodium chlo-

[1] *Rec. Geol. Surv. Ind.*, XXXV, p. 97 (1907).

[2] T. H. Holland and W. A. K. Christie, *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 154—186 (1909).

ride down to a depth of at least 12 feet, and the amount stored in these higher layers of salt cannot thus be less than about 54 million tons. Since the lake was taken over by Government in 1870-71, over 6 million tons of salt have been removed and sold away from Sambhar. During the past five years the average annual distribution amounted to 205,269 tons, most of which went to the United Provinces.

Distribution of Sambhar salt.

Table 97 shows the average annual distribution of Sambhar salt for the five years 1913-14 to 1917-18. From this table it will be noticed that Sambhar has maintained its hold on the Central Provinces and enormously increased its supplies to Bihar and Orissa. The average annual amount received by the United Provinces shows an increase of nearly 7,000 tons.

Distribution of Pachbadra salt.

The average annual despatch of salt from Pachbadra during the years 1913-14 to 1917-18 amounted to 33,679 tons, against 27,956 tons in the years 1908-09 to 1913-14. Of this amount 9,496 tons, or 28·2 per cent., remained in Rajputana; 8,867 tons, or 26·3 per cent., went to Central India; 6,154 tons, or 18·3 per cent., to the Central Provinces; 7,552 tons, or 22·4 per cent., to the United Provinces. The distribution shews a marked increase in the supply to the Central Provinces at the expense of Rajputana itself.

TABLE 97.—*Average Annual Distribution of Sambhar Salt.* (a)

—	1908-09 to 1912-13.		1913-14 to 1917-18.	
	Quantity.	*Per cent.*	Quantity.	*Per cent.*
	Tons.		Tons.	
United Provinces	117,883	*65·5*	124,570	*60·7*
Rajputana	27,601	*15·3*	29,367	*14·3*
Central India	20,154	*11·2*	18,993	*9·3*
Punjab and North-West Frontier Province.	8,753	*4·9*	8,509	*4·1*
Central Provinces	4,352	*2·4*	4,666	*2·3*
Bihar and Orissa	1,164	*0·7*	19,164	*9·3*
Bengal	...	...	...	...
Average Total	**179,907**	***100·0***	**205,269**	***100·0***

(a) Figures taken from the Administration Reports of the N. I. Salt Revenue Department. Quantities represent tons converted from figures given in thousands of maunds.

Production of rock-salt.

There has been an increase in the average annual output of rock-salt from 150,384 tons in the period 1909-13 to 177,611 tons per annum in 1914-18; this represents 11·4 per cent. of the total production of India, excluding Aden. The details are shown in table 98, from which it will be seen that the increase in production of rock-salt is due to the mines of the Salt Range, which gave an average annual output of 152,500 tons in 1914-18, against 128,247 tons in the preceding period. The increases in the case of Kohat and Mandi State are very small.

A general account of the occurrences of rock-salt in the Punjab and North-West Frontier Province will be found in a previous Review (*Records*, Vol. XXXII, pages 83, 84) and in a paper by Dr. W. A. K. Christie published in the *Records* (Vol. XLIV, pages 241—264).

TABLE 98.—*Production of Rock-Salt during the period 1914-18 compared with the period 1909-13.*

YEAR.	Salt Range, Punjab.	Kohat, North-West Frontier.	Mandi State.	Total.	*Percentage of total salt production of India.*
	Statute Tons.	Statute Tons.	Statute Tons.	**Statute Tons.**	
1914	135,519	18,239	2,792	**156,550**	*11·6*
1915	154,772	21,387	3,633	**179,792**	*10·3*
1916	160,358	19,978	4,568	**184,904**	*12·4*
1917	152,351	23,787	4,829	**180,967**	*12·7*
1918	159,497	21,260	5,085	**185,842**	*10·0*
Average for 1914-18 .	**152,500**	**20,930**	**4,181**	**177,611**	***11·1***
Per cent. of average total (1914-18).	85·9	11·7	2·4	...	...
Average for 1909-13	*128,247*	*18,448*	*3,689*	*150,384*	*11·6*
Per cent. of average total for 1909-13.	85·3	12·3	2·4	...	...

Imports and origin of foreign salt.

There was a considerable decrease, amounting to about 20 per cent. in the imports of foreign salt. The chief features of these imports during the period under review are the marked decline in imports from the United Kingdom, a large increase in the trade with Aden, a 135 per cent. increase in that with Egypt, a nearly doubled figure in the case of Italian East Africa, and declines in supplies from Spain, Arabia and Germany. Most of the salt imported is landed at Calcutta, the next largest importer being the Province of Burma, which, however, only takes a little over 60,000 tons a year.

TABLE 99.—*Imports of Salt during 1914-15 to 1918-19 compared with the period 1908-09 to 1913-14.*

—	1908-09 to 1913-14.		1914-15 to 1918-19.	
	Quantity.	*Per cent. of total.*	Quantity.	*Per cent. of total.*
	Tons.		Tons.	
United Kingdom	164,541	*29·8*	78,108	*17·6*
Aden	92,295	*16·7*	113,470	*25·6*
Spain	91,509	*16·6*	59,996	*13·5*
Arabia	65,066	*11·8*	6,437	*1·4*
Egypt	57,162	*10·3*	134,213	*30·3*
Germany	56,833	*10·3*	6,198	*1·4*
Italian East Africa	23,875	*4·3*	45,087	*10·2*
Other Countries	1,018	*0·2*	66	...
Average Annual Total	**552,299**	*100·0*	**443,575**	*100·0*

Potash Salts.

The presence of potash salts associated with the halite of the Salt Range has been known for a considerable period, and an attempt was recently made to ascertain the economic possibilities of the deposits. Dr. W. A. K. Christie visited the mines both at Khewra and at Nurpur, and found

that potash-bearing seams were fairly numerous, and ranged from ½ to 2 metres in thickness and contained from 6·8 to 14·4 per cent. of K_2O. Part of his report[1] is quoted below:-

Potassium bearing salts were discovered in the Mayo Mines in 1873 by H. Warth. The specimens collected by him, consisting of mixtures of kieserite, sylvite and langbeinite, with common salt, have been described by a number of writers.[2] The deposit, however, was lenticular and the total quantity obtained was only 15 maunds (560 kg.).[3]

On account of the great economic value of salts of potassium, chiefly for agri cultural purposes, and the restricted area of their production,—practically the whole of the world's supply comes from the North German mines,—prospecting operations were carried out in the mines of the Salt Range, and further deposits have been found, in the Mayo Mines at Khewra and at Nurpur.

. . . .

The Department of Northern India Salt Revenue, by which the mines are worked, has hitherto been concerned only with the recovery of marketable salt, of which there exists an unlimited quantity; they have, therefore, naturally altered the direction of their workings on striking a seam of marl or impure salt of any considerable thickness, and before the underlying strata were exposed. Most of the occurrences of potassium salts are overlain by marl seams, and the exposures, consequently, are neither frequent nor easily followed out.

A list of the localities where potassium salts were found in these mines is given below. The numbers refer to the chamber series, there being a distance of 21·3 metres in a direction N. 60° E. from the median line of chamber n to that of chamber $n+1$. The localities are characterised in terms of the phraseology locally current:—

(*a*) No. 9, 3 metres S. of new tram, below the top seam of Pharwala-Sujowal marl.
(*b*) No. 9, 33·5 metres from entrance of drift N. of Buggy.
(*c*) No. 9-10 pillar, 4 metres S. of new tram, 0·5 metre below marl seam.
(*d*) No. 10, drift block Pursang, 1 metre below the highest seam of the hundred-foot marl.
(*e*) No. 12, Pharwala exploring drift, 33 metres from the mouth.
(*f*) No. 12, Pharwala exploring drift, 83 metres from the mouth.
(*g*) No. 13, Pharwala, end of ten-foot drift underlying marl seam below 544 salt.
(*h*) No. 14, Pharwala, S. end of drift.
(*i*) No. 14-15 pillar, N. of old tram.
(*j*) No. 16, Pharwala drift, immediately below hundred-foot marl.
(*k*) No. 16, Pharwala drift, 1·2 metres below hundred-foot marl.

[1] Published in *Rec. Geol. Surv. Ind.*, XLIV, p. 243 (1914).

[2] G. Tschermak, *Min. Mitt.*, 1873, p. 135.
H. Warth, *Öst. Zeit. f. Bergu. Hüttenwesen*, XXIV, p. 408 (1876).
A. Tween, *Mem. Geol. Surv. Ind.*, XIV, p. 80 (1878).
F. R. Mallet, *Mineral Mag.*, XII, p. 159 (1900).

[3] F. R. Mallet, "Manual of the Geology of India," part 4, p. 33 (1887).

(*l*) No. 19, Buggy-Sujowal, below the second of the marl seams of Pharwala-Sujowal marl.
(*m*) No. 22, Pharwala, mouth of exploring drift.
(*n*) No. 22, Pharwala, 53 metres from mouth of exploring drift.
(*o*) No. 26, Pharwala, mouth of old drift, underlying highest marl seam.
(*p*) No. 26, Pharwala, Nur Mahomed's drift, in fourth highest marl seam.
(*q*) No. 27, Buggy, beneath stairway at S. end.
(*r*) No. 29, below Buggy false marl.
(*s*) No. 30, Buggy, below Buggy false marl.
(*t*) No. 31, Buggy, below false marl.
(*u*) No. 32, Buggy, below Buggy false marl.

In many of these localities the potassium bearing deposits are too small to be of any commercial value. The most important are *e*, *f*, *i*, *m*, *n*, *s* and *u*. Of these *e*, *i* and *m* are probably exposures of one seam which we may call the Sujowal-Pharwala seam, and *f* and *n* form parts of another, which we may call the Pharwala seam. The third occurrence of any importance, which may be called the Buggy seam, extends from *q* to *u* and is easily traceable.

Average samples taken across the seams *e*, *i*, *m*, *n* and *u* contained the following percentages of K_2O :—

Seam.	True thickness.	K_2O.
	Metres.	Per cent.
e	1·98	6·8
i	1·17	9·6
m	1·22	8·0
n	2·44	7·7
u	0·69	14·4

With the data available it is impossible to estimate the quantities of potassium salts which these exposures represent, but one can form a rough idea of their order of magnitude. In addition to the exposures at *e*, *i* and *m*, the Sujowal-Pharwala seam is found at *c*, where it is about 0·5 metre thick, and at *d*, where it is thinning out from a thickness of 1 metre. The exposure at *d*, 0·4 metre, is probably the same bed and it is found again at *p*, 0·2 metre in thickness. These data show that the seam decreases in thickness as it is followed up the rise, so we shall leave out of consideration exposures higher than *i*. *i* is at a distance of about 53 metres N.N.W. from the line joining *e* and *m*, whose distance apart is 220 metres. The thickness of the bed is 1·98 metres at *e*, 1·17 metres at *i*, and 1·22 metres at *m*. If we take the average of these (1·46) as the mean thickness of the seam, assume that the deposit extends to *i* with the breadth which it has between *e* and *m*, and take its specific gravity as 2·3, it would contain about 40,000 metric tons, carrying, say,

3,000 tons of K_2O. The figures are probably underestimates, for, although the bed thins out on the rise, it probably increases in thickness with depth, the lowest exposure, *e*, being also the thickest. What has been called the Pharwala seam has been met with only at two points, *f* and *n*, about 220 metres apart, both in low level exploring drifts ; as it is not even certain that they belong to the same bed, it might be unwise to do more than point out the favourable indications they afford. That at *f* is 2·4 metres thick ; that at *m* is also 2·4 metres thick, and carries 8·0 per cent. of K_2O. The Buggy seam at *s* is 0·95 metre in thickness, and at *u*, about 45 metres distant, it is 0·61 metre. The deposit thins out as it is traced up the rise, the lowest exposure, *s*, being the thickest. At *r*, for instance, whose line of strike is some 60 metres up the rise from that of *s*, it is only a few centimetres. The quantity of the deposit in sight, therefore, is not more than a few hundred tons. No excavation further down the dip had been made at the time of my visit, and the basin of deposition may, of course, be deeper at other parts.

A potash bed was found in the small mine in the magnificent gorge of Nilawan about 3 km. S.S.E. of the village of Nurpur, from which it derives its name, and 18 km. from the railway at Lilla, whither the rock salt is transported on camels. It strikes N. 40° E. and has a south-easterly dip of about 75°. A boring was made through the seam and its true thickness ascertained to be about 1·9 metres. The material from the borehole was carefully collected and may be taken as nearly approaching an average sample. It contained 13·6 per cent. of K_2O.

The deposits are all very similar in general character ; they contain common salt, kieserite ($MgSO_4,H_2O$), langbeinite ($K_2SO_4,2MgSO_4$), sylvite (KCl) and kainite ($KCl,MgSO_4 3H_2O$). Analyses of average samples from the Pharwala-Sujowal, Buggy, and Nurpur seams are given below :—

—	Pharwala-Sujowal.	Buggy.	Nurpur.
K	8·0	11·9	11·3
Na (calculated)	21·5	10·0	9·2
Mg	4·8	8·9	9·0
Cl	37·5	23·3	21·4
SO_4	22·9	39·3	39·5
H_2O	4·9	7·1	9·3
	99·6	100·5	99·7

The difficulties of obtaining pure potassium salts from such mixture are considerable, and they differ in mineralogical composition so markedly from the salt usually mined in Europe that analogous methods of treatment are inapplicable. Crystallisation from aqueous solution at any temperature is not likely to be feasible.

Were magnesium chloride ever available, the method of W. Feit,[1] by which the material is treated with a hot saturated solution of salt with a sufficient quantity of magnesium chloride to prevent the solution of magnesium sulphate, might be employed, but in the present circumstances it would probably be preferable to remove the magnesium sulphate with lime [$MgSO_4 + Ca(OH)_2 = Mg(OH) + CaSO_4$], limestone and coal of a quality good enough for burning purposes being readily available in the neighbourhood. The operations would comprise the solution of the raw material, preferably with the help of hot mother liquors, the addition of a slight excess of slaked lime of the consistency of a thin cream, the agitation of the mixture until the precipitation of the magnesium hydroxide was complete, and the filtration of the soluble portion, now consisting of chlorides and sulphates of sodium and potassium, from the insoluble calcium sulphate and magnesium hydroxide. The filtrate would then be concentrated at boiling temperature until saturated, allowed to cool and the mother liquor drained away from the crystalline product formed, the latter being subsequently recrystallised. It is of course dangerous to draw conclusions from laboratory tests as to what would occur when the same reactions are carried out on an industrial scale, but it may be recorded that from a solution in water of 150g. of a sample from the Nurpur seam, the analysis of which is given below in the first column, 20·0 g. of the product whose composition, when dried, is shown in the second column, was obtained on cooling to 10° C. the boiling saturated solution, freed as above from magnesium salts.

—	Raw material.	Concentrate.
K	11·3	44·7
Na	9·2	4·3
Mg	9·0	trace.
Cl	21·4	35·6
SO_4	39·5	15·5
H_2O	9·3	trace.
	99·7	100·1

This, it is true, represents a recovery of but 53 per cent. of the total potassium in the raw material, but by judicious use for dissolving purposes of the mother liquors obtained on crystallising, the yield could probably be increased. The mining costs would be comparatively low; they would, however, considerably exceed the Re. 1-13 per ton expended on recovery of the more easily mined rock-salt. It is difficult to estimate the value of the products that would be recovered. High grade potassium sulphate is sold in Calcutta at about Rs. 200 per ton, say Rs. 90 per ton of K, so that were the extensiveness of any of the seams definitely proved, there would appear to be an ample margin for extraction and freight charges.

[1] *Kali* III, p. 313 (1909).

Since Dr. Christie's paper appeared the subject has been again taken up by Dr. Stuart who published descriptions of the occurrences of potash at Khewra, Nurpur and Warcha. He concluded that no continuous bed of potash will be found in the Salt Range or in Kohat, the salts occurring in discontinuous lenticles and irregular foliæ. According to this observer, the prospects of obtaining potash in the Salt Range are not promising, and it is not likely to be worked profitably except as a by-product of salt-mining.[1]

Saltpetre.

[H. H. Hayden.]

Conditions essential for the formation of saltpetre.

For the formation of saltpetre in a soil the necessary conditions are (1) supplies of nitrogenous organic matter, (2) climatic conditions favourable to the growth and action of Winogradsky's so-called nitroso- and nitro-bacteria, converting urea and ammonia, successively, into nitrous and nitric acids, (3) the presence of potash, and (4) meteorological conditions suitable for the efflorescence of the potassium nitrate at the surface. An ideal combination of these necessary circumstances has made the Bihar section of the Gangetic plain famous for its production of saltpetre.

In this part of India we have a population of over 500 per square mile, mainly agricultural in occupation, and thus accompanied by a high proportion of domestic animals, supplying an abundance of organic nitrogen. With a mean temperature of 78° F., confined to an annual range of 68°, and for a large part of the year when the air has a humidity of over 80 per cent., with a diurnal range not exceeding 8° above or below 84° F., the conditions are unusually favourable for the growth of the so-called 'nitrifying' bacteria.

With a population largely using wood and cow-dung for fuel the soil around villages naturally would be well stocked with potash, and finally, with a period of continuous surface desiccation following a small rainfall, the sub-soil water, brought to the surface by capillary action in the soil, leaves an efflorescence of salts, in which, not surprisingly, potassium nitrate is conspicuous. Under these

[1] *Rec. Geol. Surv. Ind.*, L, p. 55.

TABLE 100.—*Production of Saltpetre during the years 1914 to 1918.*

—	1914.		1915.		1916.		1917.		1918.		*AVERAGE.		Per cent. of average total quantity.
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	
Bihar . . .	4,896	*76,946*	5,673	*113,147*	5,904	*143,188*	5,024·3	*122,995*	6,299·3	*154,207*	5,559·3	*122,097*	*26·6*
Bombay (Cutch) .	1	*11*	..	..	..	..	..	..	..	..	..	..	
Central India .	56·5	..	19	*144*	26·5	*572*	34	*317*	26·2	*180*	32·4	*243*	*0·1*
North-West Frontier Province.	2·2	*51*	..	..	..	..	..	..	..	..	..	..	
Punjab . .	3,520	*73,404*	5,253	*109,548*	8,140	*191,878*	9,141	*226,793*	6,946·7	*132,330*	6,600·1	*146,791*	*31·5*
Rajputana . .	405·9	*4,232*	137	*2,568*	244	*5,700*	234·2	*6,893*	245	*5,353*	253·2	*4,949*	* *1·2*
United Provinces .	6,664	*117,818*	7,035	*148,628*	10,743	*266,241*	6,855·4	*170,733*	11,223·6	*297,120*	8,504·2	*200,108*	*40·6*
TOTAL .	**15,545·6**	*272,462*	**18,117**	*374,035*	**25,057·5**	*607,579*	**21,288·9**	*527,731*	**24,740·8**	*589,190*	**20,949·2**	*474,188*	*100·0*
Value per ton .		*17·53*		*20·64*		*24·25*		*24·79*		*23·81*		*22·63*	

TABLE 101.—*Distribution of Saltpetre exported during the years 1914 to 1918.*

—	1914.			1915.			1916.			1917.			1918.			AVERAGE.		
	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of total quantity.*	Quantity.	*Value.*	*Per cent. of average total quantity.*
	Tons.	£		Tons.	£		Tons.	£		Tons.	£		Tons.	£		Tons.	£	
Ceylon	2,204·3	*28,674*	*15·4*	2,861·1	*45,393*	*13·7*	·9	*29*	..	52·5	*1,398*	*0·2*	..	..		1,023·8	*15,099*	*4·7*
China	2,463·3	*40,305*	*17·3*	1,584·6	*27,335*	*7·6*	..	..	..	..	..	..	..	..	.	809·6	*13,528*	*3·7*
Japan	..	..	..	..	..	..	1,602·7	*47,127*	*6·6*	401·9	*9,590*	*1·6*	598·4	*14,776*	*2·5*	520·6	*14,298*	*2·4*
Mauritius and Dependencies.	1,170·3	*17,778*	*8·2*	757·3	*13,408*	*3·6*	..	..	..	554·7	*14,453*	*2·1*	..	..	..	496·4	*9,128*	*2·3*
United Kingdom	6,396·8	*112,924*	*44·9*	14,805·3	*315,372*	*70·7*	21,405	*559,154*	*88·3*	23,859·7	*628,308*	*92·6*	16,941·4	*447,191*	*72·2*	16,681·6	*412,590*	*76·8*
United States of America.	958·1	*15,096*	*6·7*	..	..	..	999·2	*25,230*	*4·1*	150	*3,966*	*·6*	5,503·3	*141,947*	*23·4*	1,522·1	*37,248*	*7·0*
Other Countries	1,065	*19,987*	*7·5*	922·1	*20,876*	*4·4*	241·3	*6,584*	*1·0*	749·9	*20,141*	*2·9*	435·9	*11,908*	*1·9*	682·8	*15,899*	*3·1*
TOTAL	**14,257·8**	*234,764*	*100·0*	**20,930·4**	*422,384*	*100·0*	**24,249·1**	*638,124*	*100·0*	**25,768·7**	*677,856*	*100·0*	**23,479**	*615,822*	*100·0*	**21,736·9**	*517,790*	*100·0*

conditions Bihar has for many years yielded some 20,000 tons of saltpetre annually.

System of manufacture.

The system of manufacture has been very frequently described in detail,[1] and consists essentially in dissolving out the mixed salts contained in soil around villages, and effecting a first rough separation of the two most prominent salts—sodium chloride and potassium nitrate—by fractional crystallisation. The impure sodium chloride is consumed locally, whilst the saltpetre is sent to refineries for further purification before export.

Production and exports.

The returns for production are now much more complete than formerly, and the export figures need no longer be taken as the index to the extent of the manufacture. Output figures for the years 1914-18 are given in table 100 and export figures in table 101. It will be seen that returns of the amount produced are no longer lower than those of the amounts exported. There was a considerable increase in both production and exports during the period under review; at the same time, there was a still more marked increase in price which rose to nearly 25 shilling per cwt. in 1917, from 15·24 shillings, the price before the war. The average amount annually exported during the period was higher than it had been since the period 1878-83.

The distribution of the exports was of course determined by the war. From table 101 it will be seen that by the year 1915 most, and in 1916 and 1917 almost all, of the saltpetre exported was sent to the United Kingdom. The United States, Mauritius, Ceylon and Hongkong, which had formerly taken practically the whole output, now got only an insignificant fraction. In 1918, however, exports to the United States were resumed.

Provincial shares in the exports.

Calcutta is still, as it always has been, the chief port through which saltpetre leaves India, the exports during the period under review having amounted to 78·4 per cent. of the total, as compared with 98·46 per cent. during the preceding period. This decrease is due to the much larger share of the output produced in the Punjab and Rajputana and exported *viâ* Karachi and Bombay. Karachi's and Bombay's shares of Indian exports during the period under review amounted respectively to 14 per cent. and 7·6 per cent. as against

[1] Saltpetre: Its Origin and Extraction in India, by C. M. Hutchinson. *Agri. Res. nst., Pusa,* Bull. No. 68 (1917).

0·91 and 0·62 per cent. during the preceding quinquennium. The average annual exports from the different provinces during the period 1914-15 to 1918-19 have been :—

	Tons.
Bengal	17,266·1
Sind	3,078·3
Bombay	1,669·1
Madras	0·5
TOTAL	22,014

Trans-frontier imports.

Only very small quantities of saltpetre for chemical and medicinal purposes are imported into India by sea, but a considerable quantity comes from Nepal. During the period under review the imports from Nepal, as shown below, averaged 4,595 cwts., as compared with 9,172 cwts., during the preceding period.

	Cwts.
1914-15	838
1915-16	4,903
1916-17	6,050
1917-18	5,498
1918-19	5,686
Average	4,595

The annual values returned for the total imports give an average of £3,372 or of 14·68 shillings per cwt.

Tin.

[J. COGGIN BROWN.]

Occurrence.

The cassiterite deposits of Burma, which furnish the great bulk of India's production of this metal, have been worked from a remote antiquity, especially in Lower Tenasserim. The country in which the Burmese tin ores occur corresponds with that described below in the case of wolfram, and the two minerals are very intimately associated. The Burmese ranges are merely the northern continuation of the same rocks which have furnished the rich and well-known tin-stone deposits of the Malay Peninsula and Western Siam. The cassiterite deposits of the

Indian Peninsula have up to the present time proved of very little economic importance.

Production.

It was only natural to expect that any activity in wolfram-mining would also react favourably on the output of tin-stone. Here a word of caution in interpreting the figures given in the statistical tables for the output of cassiterite and wolfram is necessary. Concentrates are shipped from the ports in Burma as "mixed concentrates," and actually contain varying proportions of wolfram and tin ore. Thus a certain amount of tin ore escapes tabulation and goes to swell the "wolfram" or "tungsten ore" returns. In the absence of assay results, on which the parcels are sold, but which are not officially given to the Administration, it is impossible to arrive at exact figures for each. This was foreseen in the case of the Southern Shan States in the annual mineral returns for 1917. As most of this particular supply comes from one mine, the approximate assay composition, *viz.*, 43 per cent. of wolfram to 57 per cent. of cassiterite, is known, and the figures were corrected accordingly. In the cases of Tavoy and Mergui with some 130—140 producing concessions, no such correction can be applied, for the composition of parcels from the same mine varies from time to time with the season, or according to the rise or fall in price, or, again, to please the passing mood of the owner. Until some official organization collects and tabulates assay returns, the statistics must remain in their present unsatisfactory state. To any one desirous of obtaining a rough approximation at the truth the statement of the President of the Tavoy Chamber of Mines in 1919 may be helpful. He regards the approximate composition of the 13,000 tons of mixed concentrates produced in Tavoy from the outbreak of the war to the end of 1918 as WO_3=55 per cent. and Sn=15 per cent.[1]

Accepting the tabulated figures as they stand, the production of block tin in Mergui has not altered a great deal from 1,963 cwts. valued at £16,235 in 1914 to 2,013 cwts. valued at £28,123 in 1918, but the total output of cassiterite concentrates has risen from 4,275 cwts. valued at £18,706 to 15,607 cwts. valued at £106,512 in 1918. When it is considered that the greater portion of this was recovered more or less as a by-product of wolfram-mining and that it is only since the war that the actual exploitation of the ore itself

[1] *Mining Journal,* March 15th, 1919.

has in most cases taken place, the result is all the more gratifying. The imports of unwrought tin in the form of blocks, ingots, bars and slabs into India from foreign countries has fallen from 41,406 cwts. in 1913-14 to 24,977 cwts. in 1917-18. The largest quantity of this still continues to come from the Straits Settlements.

Mergui District.

In the last Quinquennial Review a short account of the geology and tin occurrences of this district has been given, which is a summary of the work of Messrs. Oldham (1855), Fryer (1871), Hughes (1899) and Page (1908). It is unnecessary to repeat this here. A brief reference may, however, be made to the later work of A. M. Heron (1916-1918).[1] All the Mergui wolfram deposits appear to carry cassiterite, and the area is comparatively richer in that mineral than in wolfram. Alluvial cassiterite workings are widely distributed over the whole district, mostly held by petty concessionaires under special short-term leases known as "Native Methods" leases. The term is self-explanatory, and it is to be regretted that most of the tin ore from Mergui is still obtained in such a fashion. The output of ore has not varied much from 1,861 cwts. in 1914 to 1,471 cwts. in 1918.

TABLE 102.—*Consumption of Foreign Block Tin in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption.
	Quantity.	*Value.*		
	Cwts.	£	Cwts.	**Cwts.**
1913-14	41,406	*423,282*	4,096	**37,310**
1914-15	37,877	*314,607*	1,421	**36,456**
1915-16	28,361	*243,521*	860	**27,501**
1916-17	27,965	*259,003*	1,740	**26,225**
1917-18	24,977	*275,225*	1,749	**23,228**
Average	32,117	*303,128*	1,973	**30,144**

[1] J. Coggin Brown and A. M. Heron, "The Distribution of Ores of Tungsten and Tin in Burma." *Rec. Geol. Surv., Ind.*, L, pp. 117-119.

TABLE 103.—*Production of Tin and Tin-ore in the Indian Empire during the years 1914 to 1918.*

—		Mergui.		Tavoy.		Amherst.		Thaton.		Southern Shan States.		Hazaribagh.		TOTAL.	
		Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
		Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£
1914	Tin	1,963	*16,235*	..	..	..	..	..	..	..	..	1·0	*16*	1,984	*16,251*
	Tin-ore	1,861	*9,263*	767	*3,696*	..	..	..	..	1,647	*5,747*	..	..	4,275	*18,706*
1915	Tin	2,553·5	*20,534*	·6	*4*	..	..	..	..	..	..	·7	*6*	2,554·8	*20,544*
	Tin-ore	1,762·2	*8,678*	253	*956*	..	..	..	..	3,769·9	*13,155*	..	..	5,785·1	*22,789*
1916	Tin	2,257·2	*19,802*	..	..	..	..	..	..	..	..	..	..	2,257·2	*19,802*
	Tin-ore	1,897	*10,531*	1,644	*8,192*	10	*16*	900	*3,598*	4,862	*16,965*	..	..	9,313	*39,302*
1917	Tin	2,817·9	*27,962*	..	..	..	..	..	..	..	..	..	..	2,817·9	*27,962*
	Tin-ore	1,761	*10,930*	1,762	*11,015*	33	*176*	1,677	*3,972*	8,088	*40,440*	..	..	13,321	*66,533*
1918	Tin	2,013·6	*28,123*	..	..	..	..	..	..	..	..	..	..	2,013·6	*28,123*
	Tin-ore	1,471·2	12,432	4,052·7	*31,056*	1,317·5	*8,767*	1,157	*2,896*	7,609	*51,361*	..	..	15,607·4	*106,512*
Average	Tin	2,321	*22,531*	·1	*1*	..	..	..	..	..	..	(a)·3	4	2,321·4	*22,536*
	Tin-ore	1,750·4	10,367	1,695·8	10,983	272·1	1,792	746·8	2,165	5,195·2	25,533	..	..	9,660·3	50,840

(a) Average of 5 years.

TABLE 104.—*Exports of Burmese Block Tin and Tin-ore for the years 1913-14 to 1917-18.*

Year.	Block Tin.		Tin-ore.		Total.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity Tin-ore.(a)	*Value.*
	Cwts.	£	Cwts.	£	Cwts.	£
1913-14 . .	12	*115*	4,200	*24,373*	**4,218**	*24,488*
1914-15 . .	...	...	2,300	*12,934*	**2,300**	*12,934*
1915-16 . .	1	*8*	1,740	*8,815*	**1,741·5**	*8,823*
1916-17 . .	1	*5*	4,280	*23,448*	**4,281·5**	*23,453*
1917-18 . .	...	...	6,000	*42,396*	**6,000**	*42,396*
Average .	3	*26*	3,704	*22,393*	**3,708·2**	*22,419*

(*a*) 3 cwts. of the ore are assumed to be equivalent to 2 cwts. of block tin.

The best-known centres are Karathuri on the coast and Thabawleik on the Little Tenasserim river. Numerous blocks have been taken up on the Lenya and Pakchau rivers. Licenses have been issued to Europeans near Karzat and Kyumon in the delta of the Tenasserim, near Palaw and Palauk and in certain islands of the Mergui Archipelago. On Spider island, at the mouth of the Palauk river, is an interesting area in which concentrates containing cassiterite and wolfram in about equal amounts are obtained from the sea beach and from below high water level in a mangrove swamp. They are derived from thin, irregular veins traversing a little hill rising above the swamp. Attention has been drawn in the last Quinquennial Review to the Burma Development Syndicate's property at Maliwun. This was originally worked by the Chinese, subsequently by the Jelebu Co., Messrs. Strang, Steel & Co. and by the present Syndicate. The mine was lavishly equipped with modern plant, but has never been able to pay, and the hydro-electric generators, mill, air compressor, hydraulicing plant and electric tramways are now rusting in the jungle, and only a small gang of Chinese tributers carry on work. The quartz-veins and greisens carry white mica, pyrite, chalcopyrite,

arsenopyrite and cassiterite. They occur in granite close to its margin with the sedimentary strata of the Mergui Series. Careful systematic boring of the Mergui cassiterite-bearing alluvial deposits of Mergui is as essential to-day as ever it has been in the long history of the district, and until this has been done, the development of the industry will continue to be retarded.

Tavoy District.

Geological conditions in Tavoy district are much the same as those in Mergui. Granite intruded into an ancient sedimentary series forms the cores of the high north and south trending ranges; quartz veins and pegmatites carrying wolfram, cassiterite, molybdenite, bismuth, bismuthinite and a large variety of sulphides cut through both. These minerals occur in the alluvial deposits of the hill slopes, where veins are undergoing degradation, and in the coarse unsorted debris of clay boulders and rotten rock which tends to accumulate at the heads of the flatter valleys. Cassiterite is found also in the true, water-sorted gravels and sands, the alluvial deposits proper, of the flatter portions of the streams. Since the publication of the last Quinquennial Review, much has been written on the geology, mineralogy and economics of the Tavoyan deposits, and a geological map of the district is available.[1] To these the reader is referred for further details.

Large quantities of cassiterite mixed with wolfram are won by vein mining at the Burma Queensland Corporation mine at Hermyingyi, where also the detrital deposits are treated by monitoring during the rains, from the Taunghila group of mines and from gravels by monitoring at Myekhanbaw.

The expected resuscitation of the former Hindu Chaung Tin Dredging Company referred to in the last Review has taken place through the energies of Messrs. H. Booth and J. J. Milne, who, as the pioneers of tin dredging in Burma, deserve the success they have attained. To the work of the late Mr. C. M. Lyons, O.B.E., India owes its first electrically operated pump dredge, which is now exploiting the deep tin-bearing grounds at the Kanbauk mine in Tavoy. The insistence by the Geological Survey officers that the river gravels of the district were worth systematic testing for cassiterite has resulted in numerous areas being taken up by large firms, and the end of the period under review witnessed the beginning of

[1] *Rec. Geol. Surv. Ind.*, L., pl. 27.

a regular boring campaign throughout the more accessible parts. The output of the ore from Tavoy has risen from 767 cwts. in 1914 to 4,052 cwts. in 1918, but a certain amount of this is due to the magnetic separation from mixed concentrates of wolfram and cassiterite. A large increase in the output of the ore from this and other parts of Tenasserim should be registered in the next quinquennial period.

Amherst District.

The Amherst or Moulmein district lies to the north of Tavoy, and its production of tin ore has risen from 10 cwts. in 1916 to 1,317 cwts. in 1918. There are three producing localities at present, but prospecting is being carried on in other parts, and it is probable that further discoveries will be made.

On Belugyun island at the mouth of the Tenasserim river the deposits are on the lower slopes of argillaceous quartzites, which form the backbone of the island. These rocks are penetrated by veins of tourmaline-garnet pegmatite, fine-grained foliated, tourmaline granite and drusy white quartz. The cassiterite may come from any or all of these. The other localities are west and east respectively of the Seludaung range which divides the coastal plain from the valley of the Winyaw, a tributary of the Ataran. Various concessions on which alluvial cassiterite occurs have been taken out around Sakaugyi village and near Paya and Hlutsha to the south-south-east of Seludaung G.L.S. The tin-ore appears to come from the granitic rocks which pierce the sedimentary strata in these regions.

Thaton District.

This district produced 900 cwts. of tin-ore in 1916, 1,677 cwts. in 1917 and 1,157 cwts. in 1918. The cassiterite and wolfram areas are all situated on the long ridge which runs parallel to the railway from Pegu to Martaban.

The two tin concessions are at the extreme ends of the line of wolfram-bearing areas. That to the north (Kadeik) is a small but rich alluvial area on which a gravel pump or a barge is operated. No cassiterite-bearing veins have been discovered. The other is a small patch of alluvial ground in which the cassiterite is derived from small veins and stringers in the underlying rocks. These notes on Thaton, Amherst and Mergui are a summary of observations made by Mr. A. M. Heron of the Geological Survey of India.

Southern Shan States.

The output from the Southern Shan States comes from the Mawchi mine, which is situated in the southern portion of the Bawlake State, Karenni. It has risen from 1,647 cwts. in 1914 to 7,609 cwts. in 1918, reaching a maximum of 8,088 cwts. in 1917. There are at least ten important veins varying from 2½ to 5 feet in thickness, in granite country rock and carrying cassiterite, wolfram, arsenopyrite, pyrite, chalcopyrite and black tourmaline. The veins are worked by modern methods, and successful exploration has been carried out to a greater depth than on any other deposit of this kind in Burma.

Indian Occurrences.

The Nurunga deposit mentioned in the last review is now being worked by Messrs. Sunder Mull & Co. of Giridih, who have purchased the property from Mr. P. N. Bose. Cassiterite occurs occasionally in the mica-bearing pegmatites in the province of Bihar and Orissa as minute crystals disseminated through the lepidolite at Pihra and in crystals up to ⅛ inch at Simratari, west of Pihra.[1] According to Mr. G. H. Tipper, more recently Mr. J. F. Podger found some large fragments of cassiterite crystals in a pegmatite intrusive into "dome" gneiss about 2 miles south of Domachanch village, Hazaribagh district. It is here associated with green microcline, green tourmaline, zircon and quartz crystals.

Tungsten.

[J. COGGIN BROWN.]

Increased demand.

The outstanding feature of the period under review was the unprecedented demand for tungsten ores created by the rapid development of munitions manufacture as a consequence of the war. Prior to this period, Great Britain was practically dependent upon Germany for supplies of ferro- and metallic tungsten notwithstanding the fact that Lower Burma then headed the list as the world's greatest producer of wolfram. The erection in England of large tungsten-producing plants like those of the High Speed Steel Alloys Co., Ltd., the Thermo-Electric Syndicate, Ltd., and others at once led to intensive operations on all the tungsten ore deposits of the Empire, and the manner in which Lower Burma responded to these is described briefly below.

[1] F. R. Mallet: *Rec. Geol. Surv., Ind.,* VII, p. 43: T. H. Holland: *Mem. Geol. Surv., Ind.,* XXXIV, p. 50.

Uses.

In the last Quinquennial Review there is a paragraph dealing with the uses of tungsten, and it is stated that over four-fifths of the total outturn is absorbed in the manufacture of high speed steel cutting tools. The tendency during the five years under review seems to have been to increase the proportion of the element in these alloys, so that they now contain from 13 per cent. to 20 per cent. of tungsten, while certain special varieties are said to carry more. Such steels have increased remarkably the efficiency of both machinists and lathes as may be gathered from the following quotation from a recent American publication: -" Manufacturers working large groups of men say that from three to five times as much metal can be cut with such a steel as with the old simple carbon steel. In other words, under favourable conditions one man and one lathe can do as much work with high speed tungsten steels as five men and five lathes could formerly do with simple carbon steels." [1]

The greatly extended use of tungsten filament lamps throughout the world, with a corresponding saving of power, is another development which may be referred to here. The actual amount of the metal absorbed by this industry is insignificant from the mining point of view, however, although about 200 millions of such lamps were manufactured in the United States alone in 1916. Owing to the high prices of platinum, the use of tungsten in place of platinum points in dental work increased rapidly during the war. "The total consumption of tungsten for purposes other than steel approximated 5 tons or about 10 tons of 60 per cent. concentrates, that is, about one half of one per cent. of the United States' total production." (C. G. Finck "The Mineral Industry, 1917", p. 704.)

Burma and the World's Production.

Up to the year 1915 Burma continued to be the largest wolfram-producing country in the world. The action of the British Government in taking the whole output of the British Empire for home uses in that year, and the large war orders placed by the allies in America for munitions and special steels resulted in a spectacular boom in tungsten-mining in that country. It continued throughout 1916, and in that year 6,790 metric tons of 60 per cent. concentrate were produced. In 1917, out of a world's production of 21,000 metric tons, the United States of America produced 5,000 metric tons and

[1] "Tungsten Minerals and Deposits" by Frank L. Hess, Bull 652, U. S. G. S., 1917, pp. 15 and 16.

Burma 4,800 metric tons, according to the official figures of the United States Geological Survey (The Mineral Industry, 1917, p. 718). Considerable quantities of wolfram were obtained in 1917 and 1918 from China, where it is found in the provinces of Hunan and Kwangtung. Although reliable data are difficult to obtain at the time of writing, it is believed that the Chinese deposits are of very considerable value and will eventually be serious competitors for the world's market.

Wolfram in Burma.

The earlier records of the occurrence of wolfram in Burma date back to the forties of last century and refer mainly to the injurious effects the mineral had on the value of tin concentrates when mixed with them, or to the efforts of misguided individuals to extract metallic tin from pure wolfram concentrates. It was not until the year 1908, when Mr. J. J. A. Page, then a member of the Geological Survey of India, discovered the wolfram-cassiterite pegmatites of Pagaye, that modern attention was directed to the mineral, and the field began to be explored and opened out. Shipments started with 7 tons in 1909 rising to 395 tons in 1910, and during the five years 1909-13, over 5,000 tons, with a value of nearly £406,000, were produced. By far the greater proportion of this came from Tavoy, though Mergui, the Southern Shan States and a locality in the Central Provinces added a little to the total. In the year 1914, 2,243 tons were produced, of which Tavoy alone yielded nearly 2,000 tons. This year witnessed a slump in the market, and mining operations were at a very low ebb. In 1915 a shortage of tungsten ores became evident in England, and, as a consequence, steps were taken to increase the output of the raw material as far as possible; all wolfram produced in the British Empire was ear-marked for despatch to the United Kingdom, and all shipments reaching British ports were taken over by the Imperial Government at a fixed rate of 55*s*. per unit of WO_3 on a basis of 65 per cent. ore, and were distributed to manufacturers through brokers appointed for the purpose.

The response to this increase in price was neither immediate nor satisfactory as far as Tavoy was concerned. Mining methods were, with few exceptions, exceedingly primitive, the labour force was under-manned, inexperienced and fluctuating with the sporadic migration of Burmese to the mines between the agricultural seasons; means of communication and transport were difficult and slow, and there was much lack of enterprise and failure to work up to the

obligations imposed on them by their titles on the part of many owners.

In September, 1915, the Director of the Geological Survey of India, and the Controller of Munitions in Burma, arrived in Tavoy and conferred with the Local Chamber of Mines and the Deputy Commissioner, regarding the steps to be taken to stimulate output. As a consequence, the Deputy Commissioner, Mr. W. B. Brander, was appointed special officer in charge of the mining administration and vested with powers from the Local Government enabling him to insist on concessionaires fulfilling the terms of their contracts by working energetically and efficiently. In October, 1915, Mr. J. Coggin Brown, of the Geological Survey of India, joined Mr. Brander as technical adviser, and with him were associated Mr. A. M. Heron and Sub-Assistants S. Sethu Rama Rau and M. Vinayak Rao, the one to assist in the detailed examination of existing properties with a view to their intensive development, and the other to prospect for new mineral-bearing areas.

In addition to these measures, a large labour force was imported from China and the Straits Settlements, a Protector of Chinese was appointed to control and settle disputes amongst the coolies, a comprehensive programme of road construction throughout the field was initiated, a mining advisory board was set up, and many of the large firms of the province interested themselves in the mining business. A systematic geological survey of the district was commenced in 1916 and a preliminary geological map published in 1919. This work was carried out by Mr. A. M. Heron and the sub-assistants already mentioned.

That these measures were attended with success is shown by the fact that Burma's output for 1916 was 3,650 tons, or considerably more than double the output of any year previous to the war, and that, out of a total of 17,366 tons for the quinquennial period, Tavoy alone produced 14,377 tons valued at nearly 2 millions sterling. A certain amount of cassiterite is contained in this concentrate, and attention is invited to the chapter on "Tin," where the matter is discussed.

During the period under review, wolfram has been found in a number of new localities in Burma which now stretch from the Southern Shan States, through Bymgyi in the Yamethin district, Mawchi in Karenni, and various places in the Thaton, Amherst,

TABLE 105.—*Production of Tungsten ore during 1914 to 1918.*

—	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa—												
Singhbhum	..	..	..	..	8	*640*	20	*1,333*	2·5	*498*	6·1	(a) *494*
Burma—												
Kyaukse	..	..	..	..	..	..	..	..	·1	*17*	..	(a) *3*
Mergui	194	*16,647*	232·3	*29,554*	340	*46,014*	368	*49,541*	376·6	*52,490*	302·2	*38,849*
Southern Shan States	56	*5,600*	142·2	*14,220*	185	*18,500*	307	*39,910*	287	*41,615*	195·4	*23,969*
Tavoy	1,976·6	*152,333*	2,032·9	*235,827*	3,034	*410,586*	3,697·5	*508,794*	3,636·1	*610,833*	2,875·4	*383,675*
Thaton	17	*570*	49·4	*6,589*	91·5	*15,079*	107·5	*15,366*	91·5	*13,663*	71·4	*10,253*
Central Provinces—												
Nagpur	..	..	..	..	1·3	*220*	..	..	..	..	·3	(a) *44*
Rajputana—												
Marwar	..	..	..	..	32·7	*6,358*	42	*8,130*	37·4	*7,565*	22·4	(a) *4,411*
TOTAL	2,243·6	*175,150*	2,456·8	*286,190*	3,692·5	*497,397*	4,542	*623,074*	4,431·2	*726,681*	3,473·2	*461,698*

(a) Average of 5 years.

Tavoy and Mergui districts, to Maliwun in the extreme south of Mergui, a distance of approximately 750 miles. In most of these places it is associated with varying amounts of cassiterite.[1] The quartz-veins, pegmatites and greisens, which carry the minerals, have their origin in the intrusive granites forming the cores of the mountain ranges of the Indo-Malayan system. The granite is intruded into a series of ancient slates, argillites, clay schists and silicified tuffs with subordinate quartzites and conglomerates of unknown age, known as the Mergui series in the southern parts of Tenasserim. The veins may occur in either the granite or the old sedimentary rocks, and are often observed passing from one to the other. Detrital or eluvial deposits of wolfram and cassiterite occur on hill slopes in which the veins outcrop. Alluvial and ancient beach deposits containing cassiterite occur in the river valleys below them. Wolfram does not occur in true alluvial deposits unless it is protected by a quartz matrix.

In different parts of the province the mineral association of the ores is not the same. Beryl has only been found at Bymgyi; at Mawchi, in Thaton and in parts of Mergui, tourmaline occurs, but it is unknown in Tavoy, where large quantities of pyrite and smaller amounts of other sulphides, with small, though widely prevalent quantities of fluorite are the associated minerals.

The period of the war has not only witnessed a remarkable expansion of wolfram-mining in Burma, but it has also seen the foundation of a permanent industry on modern scientific lines. Although the hand-to-mouth prehistoric methods of the Chinese miner survive to a certain extent on the smaller properties, the larger and more valuable ones are now in the hands of firms possessing capital and under the control of experienced mining engineers. Deep-level development work is progressing rapidly, concentrating plants embodying the latest practice have been erected, aerial ropeways installed, hydro-electric generating stations built, and magnetic separating machinery erected. Extended use is also being made of water-power for hydraulicing the eluvial deposits, and there seems no reason to fear that Burma will not be able to hold its own place in the world's market, given a reasonable price for its concentrates, in the future.

[1] See the literature quoted under "Tin."

Singhbhum. A small deposit of wolfram discovered in the Dharwarian rocks near Kalimati, B. N. R., has been worked during the years 1916 to 1918 by Messrs. Andrew Yule & Co., with a total yield of 30·5 tons. The ore occurs in pockets in quartzite at the junction with overlying micaceous schists, and has been followed on the dip by means of an inclined shaft, but work has now been abandoned. The quartzite referred to above is a composite one consisting of a sedimentary quartzite with interbedded sheets of vein quartz: and the introduction of the wolfram is probably to be correlated with the intrusion of the vein quartz.

Central Provinces. In 1916, old wolfram-bearing dumps were cleaned up at Agargaon in the Nagpur district, and the insignificant total of 1·3 tons of wolfram were recovered and exported.

Rajputana. Over 100 tons of wolfram were produced from the Degana mine in the Marwar district of Rajputana during the years 1916-1918. The mineral occurs in thin quartz veins which contain coarsely crystallised mica, ilmenite and fluorite. The country rock is granite. Mining operations are considerably hampered owing to the lack of water.

Zinc.

[J. COGGIN BROWN.]

Zinc concentrates are produced at the Bawdwin mines, where zinc blende occurs in association with argentiferous galena (see under LEAD AND SILVER, *supra*, p. 136). The exports have been as follows:—

—	Tons.	Value in £.
1914	8,553	10,762
1915	196	Not stated.
1916	3,224·6	16,266
1917 and 1918	*Nil*	...
TOTAL	11,973·6	27,028

In the years 1913 and 1914 considerable quantities of zinc concentrates were shipped to Belgium and Germany for conversion into spelter. The shipments of 1916 went to Japan for the same purpose. Large tonnages of zinc concentrates will be available on the completion of the new milling plant at Nam Tu, and it is proposed to erect a reduction works at Sakchi capable of treating a portion of these on a scale of 70 tons of concentrates per day, containing 48 per cent. zinc and 30 per cent. sulphur, with a production of 24 tons of spelter and 90 tons of chamber acid, equivalent to about 10,000 tons of spelter and 32,000 tons of acid per annum.[1]

Except at Bawdwin, ores of zinc are not known to occur in any quantity in the Indian Empire; they have been found associated with the antimony-ores of Shigri in Lahaul, with the silver-lead ores of Bawdwin in the Northern Shan States, and with the copper-ores of Sikkim. No successful attempts to extract the metal have yet been made by Europeans, but up till about a century ago, zinc was extracted from carbonate of zinc (smithsonite) at Jawar or Zawar in Udaipur State, Rajputana.

[1] L. L. Fermor. Indian Munitions Board Handbook, 1919, p. 144.

IV.—MINERALS OF GROUP II.

Alum and Bauxite.

[H. H. HAYDEN.]

Alum.

The separation of sulphate of alumina from decomposed pyritous shales, and the preparation of the double sulphate of alumina and potash, by the introduction of nitre or wood-ashes, was formerly an important industry in a few places, and, on a smaller scale was practised at numerous places, in India. But the importation of cheap alum, principally from the United Kingdom, and its wide distribution by the gradually extending system of railways, have now nearly killed the native industry. Table 106 shows that during the five years 1914-15 to 1918-19 the consumption of foreign alum in India has averaged 107,325 cwts. as compared with an average annual consumption of 73,626 cwts. during the preceding five years.

TABLE 106.—*Consumption of Foreign Aluminous Sulphates (including Alum) in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption of foreign alum.
	Quantity.	*Value.*		
	Cwts.	£	Cwts.	**Cwts.**
1914-15	126,805	*36,433*	2,374	**124,431**
1915-16	131,895	*55,266*	13,591	**118,304**
1916-17	155,283	*88,968*	18,927	**136,356**
1917-18	103,206	*87,721*	6,618	**96,588**
1918-19	65,648	*49,107*	4,702	**60,946**
Average	*116,567*	*63,499*	9,242	**107,325**

The only portion of India for which regular returns of output are available is the Mianwali district, Punjab, where, during the five years under review, there was an average annual production of 6,375 cwts. valued at £3,981 (see table 107). For the years 1910 to 1913 figures were received from Cutch, where there still languishes an

ancient alum industry that was formerly much more extensive[1]; but the whole output for those four years was only 709 cwts. and no figures are available for the period now under review.

In the Punjab the raw material is a pyritous shale of Eocene age found at Kalabagh, Kotki, and other localities in the Isakhel tahsil. The average sulphur-content in the workable patches of these shales is, according to the late Mr. N. D. Daru,[2] 9·5 per cent. After roasting, the shale is lixiviated and concentrated. A mixture of crude chlorides, nitrates, and sulphates, of sodium (chiefly) and potassium is then added, the alum crystallised out, and then fused in its water of crystallisation and allowed to recrystallise. The product is mainly soda-alum, and is used at Delhi, Hissar, Sirsa, and other centres of the tanning and dyeing industries. The alkaline salts used are obtained by concentrating and crystallising the product of lixiviation of the scrapings of the soil of various localities in the Mianwali and Shahpur districts. Pyritous shale, suited for the manufacture of alum, is also found at Dandot and Pidh in the Salt Range. The pyritous shale treated at Madh in Cutch is also of Eocene age.

Alunite.

Alunite, a sulphate of aluminium, is found associated with sulphur in veins traversing Siwalik clays in the Sanni sulphur mines in Kelat, Baluchistan.[3]

TABLE 107.—*Production of Alum in Mianwali District, Punjab, during the years 1914 to 1918.*

YEAR.	Quantity.	*Value.*
	Cwts.	£
1914	8,674	*4,642*
1915	7,026	*4,393*
1916	9,419	*6,205*
1917	5,434	*3,707*
1918	1,322	*960*
Average .	*6,375*	*3,981*

[1] *Manual of the Geology of India*, pt III, p. 432 (1881).
[2] *Rec. Geol. Surv. Ind.*, XXXVIII, p. 32 (1909); XL, pp. 265—282 (1910).
[3] G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 214 (1909).

Bauxite.

Some years ago it was discovered that many of the lateritic deposits of India are highly aluminous, such aluminous varieties being identical with the substance known as bauxite. Field-work carried out since 1903 by the officers of the Geological Survey has revealed the existence of extensive deposits of this mineral substance in various parts of India, and chemical investigation in the Geological Survey Laboratory and at the Imperial Institute has shown that certain of the Indian bauxites compare very favourably with the Irish, French, and American bauxites placed on the English market.

The richest areas yet discovered in India are the Baihir plateau in the Balaghat district and the neighbourhood of Katni in the Jubbulpore district, both in the Central Provinces. But valuable ores have also been found in Kalahandi State and Chota Nagpur, Bihar and Orissa, in Bhopal and Rewah States, Central India, in the Satara district, Bombay, and in Jammu. The bauxites to which the most attention has been up to the present devoted are those of Balaghat and Jubbulpore. Eight analyses of specimens and samples of the Balaghat bauxites have given results ranging between the following limits :—

Alumina, Al_2O_3	51·62 to 58·83
Ferric oxide, Fe_2O_3	2·70 to 10·58
Titanic oxide, TiO_2	6·22 to 13·76
Silica, SiO_2	0·05 to 2·65
Combined water, H_2O	22·76 to 30·72
Moisture	0·40 to 1·14

corresponding to 71·2 to 80·8 per cent. of Al_2O_3 after calcination. With these may be compared the following figures showing the range of analysis of some Irish, French, and American bauxites of commerce analysed at the Imperial Institute :—

Al_2O_3	42 to 63
Fe_2O_3	2 to 21
TiO_2	2 to 6
SiO_2	3 to 13
H_2O	12 to 28
Moisture	5 to 16

Two Katni bauxites gave the following analyses :—

	No. 1.	No. 2.
Al_2O_3	65·48	52·67
Fe_2O_3	3·77	7·04
TiO_2	11·61	7·51
SiO_2	0·38	1·26
H_2O	19·38	29·83

From these figures it will be seen that the Balaghat and Jubbulpore bauxites are of very high grade. There seems also to be little doubt that large quantities of the mineral are available, and the commercial feasibility of making use of these deposits has consequently been under investigation for some years. There are three ways in which the Indian bauxites might be developed :—

(1) simple export of the raw or calcined material to Europe or America for use in the alumina factories;
(2) manufacture of pure alumina locally by extraction with alkali, and export of the pure oxide to European or American aluminium works;
(3) manufacture of the metal in India.

The first proposal is impracticable on account of the low prices of raw bauxite at European ports, whilst the third would involve a heavy capital outlay under untried conditions. The second proposal involves much smaller risks, and it has been found on investigation that there are no technical difficulties in the way of manufacturing alumina from Indian bauxites.[1] Several concessions have been taken out for working the bauxites of the Central Provinces, in the practical investigation of which considerable progress has been made.

The Katni bauxites.

The occurrence of aluminous laterite at Tikari near Katni, Jubbulpore district, was first noted by Mr. F. R. Mallet in 1883.[2] In 1905, after the Geological Survey had drawn attention to the identity of aluminous laterites with bauxite, prospecting licenses were taken out by various persons interested in mineral development. Subsequently a syndicate was formed to work the Katni deposits: its objects included the manufacture of hydrated alumina, alum, and aluminium; of cement and lime; and of pottery, fire-bricks, etc., materials for all these purposes being found within the bauxite concessions.

In August 1912 the Katni Cement and Industrial Company, Ltd., was floated to acquire the Katni properties of the above syndicate, including the bauxite deposits. The cement works commenced operations in December 1914. Works have also been erected at Katni for the manufacture of tiles, piping, fire-bricks and bauxite bricks.

[1] *Rec. Geol. Surv. Ind.*, XXXV, p. 29; XXXVI, p. 220.
[2] *Rec. Geol. Surv. Ind.*, XVI, p. 113.

Table 108 shows the production of bauxite in India during the period under review; the total output for the five years amounted to 4,695 tons valued at £2,038 as against 2,244 tons, valued at £591, during the preceding quinquennium.

TABLE 108.—*Production of Bauxite in India during the period 1914-18.*

—	Quantity.	*Value.*
	Tons.	£
1914	514	32
1915	876	29
1916	750	463
1917	1,363	620
1918	1,192	894

During the last few years, increasing attention has been given to the subject of aluminium manufacture in this country, and various tentative schemes have been put forward; one of these was a proposal to employ the Serpek process for the extraction of aluminium. In this process a mixture of bauxite and coal is heated in an electric furnace with the production of aluminium nitride. The nitride is treated with a solution of caustic soda with the formation of sodium aluminate and ammonia: the alumina is extracted from the aluminate in the ordinary way and the ammonia is converted into ammonium sulphate. Had it not been for the war, it is probable that some of the schemes would have materialised. The chief difficulty, however, is the lack at present of cheap hydro-electric power. It is hoped, however, that when the large reservoir now being constructed by Messrs. Tata Sons & Co., in the Western Ghats is completed, this difficulty may be removed. Sufficient attention, however, does not seem to have been paid to the Himalayan rivers in this connection; this is no doubt due to the supposed absence of bauxites in those regions. Recently, however, large deposits have been discovered by Mr. C. S. Middlemiss, Superintendent of the Kashmir Mineral Survey, in the Sangarmarg and adjacent coalfields of the Jammu province. With coal on the spot and a potential source of hydro-electric power in the Chenab only a few miles distant, the possibilities of the manufacture of the metal by the ordinary processes appear to be well worthy of consideration.

Amber.

[E. H. PASCOE.]

Production.

The production of amber during the five years 1914 to 1918 is shown in table 109. The average annual production was 18·4 cwts. valued at £15·2 per cwt. compared with 29 cwts. valued at £6·3 per cwt. during the five years 1909 to 1913. The decreased production of amber is attributed partly to the rival attractions of rubber plantations and jadeite mining. The right to collect a 5 per cent. *ad valorem* royalty on amber in the Myitkyina and Upper Chindwin districts is farmed out with the jadeite royalties (see page 125).

TABLE 109.—*Production of Amber in the Myitkyina District, Upper Burma.*

YEAR.	Quantity.	*Value.*
	Cwts.	£
1914	13	*274*
1915	11·5	*199*
1916	5·5	*157*
1917	59·1	*684*
1918	2·9	*87*
Average	*18·4*	*280*

Occurrence.

The Burmese diggings for amber are situated in the Hukong valley in the Nangotaimaw hills between Mainghkwan and Lalaung villages in about lat. 26° 20′ and long. 96° 30.′ The substance is found in pits from 20 to 40 feet deep, in blue clay of probable Miocene age; these pits are dug in a haphazard way and are occasionally joined up by underground connections. Fragments of amber have been similarly found in association with beds of this age in other parts of Burma, for example at Mantha in the Shwebo district, and are said to have been met with on the oil-field of Yenangyat in the Pakokku district. Where definitely known it is usually associated with lignite or coal. Most of the material is brought from the Hukong valley in Upper Burma to Mandalay, where beads for rosaries, *nadaungs* (ear-cylinders), and other trinkets for personal ornament are made from the transparent varieties.

Chemical and physical properties.

The amber of Burma differs in chemical and physical characters from previously known varieties and the name *burmite* has been consequently suggested for it

as a specific distinction.[1] The well-known amber of Eastern Prussia contains from 2½ to 6 per cent. of succinic acid and is known to the mineralogist as *succinite;* the Burmese amber is harder and denser, and it is doubtful whether it contains any succinic acid, though the products of its dry distillation include formic acid and pyrogallol. Its ultimate chemical composition has been determined to be as follows:—

Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
	100·00

The specific gravity of burmite varies between 1·030 and 1·095. It is distinguished from many other amber-like resins by its superior hardness and greater toughness, which render it fit for carving and turning. It varies in colour from pale yellow to dull brown, and possesses a peculiar flourescence, like that which distinguishes the Sicilian variety simetite.

Apart from the occurrence of a large percentage of discoloured opaque pieces, many of the large fragments obtained are damaged by cracks filled in with calcite; but otherwise there appears to be a large quantity of material which might be put on the market with profit.

Antimony.

[E. H. PASCOE.]

A mining lease to work the well-known antimony-ores (stibnite with oxides) near the Shigri glacier in Lahaul was granted in 1904 to Colonel R. H. F. Rennick. The stibnite lodes are associated with gneissose granite and are situated at an elevation of 13,500 feet; to reach the locality it is necessary to cross the Hamta Pass (14,500 feet). Work is possible for two or three months only in the year, and labour and supplies have to be brought from the nearest village, 3½ marches away. In spite of these difficulties, however, Colonel Rennick succeeded in 1905 in shipping over 400 maunds (15 tons) of stibnite to England. Since then further quantities have been quarried and his deposits are thought to be extensive enough to yield 200 to 400 maunds of stibnite a year, but no further shipments were made on account of the low price of star regulus. The stibnite has yielded 6 dwts. of gold per ton. Galena and blende are also found in the same locality, the former being argentiferous.

[1] O. Helm, *Rec. Geol. Surv. Ind.*, XXV, p. 180 (1892), and XXVI, p. 61 (1893).

The existence of an antimony deposit of considerable size in the Möng Hsu State, one of the Southern Shan States, is indicated by the return amongst the mineral statistics for Burma for 1908 of an output, under a mining lease held by Mr. W. R. Hillier of Lashio, of 1,000 tons of antimony-ore, of which 11 tons were sent to London for assay and valuation. The output from the Southern Shan States in the following year was recorded as 2½ tons, since when there have been no returns. Further details regarding these deposits are being published in the Records of this department by Mr. H. C. Jones, who concludes that none of them appears to be large or of much economic value.

In 1905, stibnite with cervantite was found in the Northern Shan States,[1] whilst the lead slags at Shekran in Jhalawan, Baluchistan, are antimonial.[2] The tetrahedrite found in the Sleemanabad copper lodes[3] is also highly antimonial. A few pounds of antimony-ore are recorded from the Jhelum district, Punjab, for the years 1914 to 1918. A small quantity, amounting to 13 tons, of stibnite was produced in the Amherst district of Burma. In response to a considerable demand for antimony during the year 1916, this supply, derived from two or three localities, was increased to 1,000 tons, but fell to 105 tons in 1917 and to *nil* in 1918. Dr. A. M. Heron has recently investigated these occurrences and concludes that, at the present price of antimony, some of them could be profitably exploited: a description of his work is being published shortly in the Records of this department. Mysore responded to the same stimulus but the production fell to ·1 ton in 1918.

TABLE 110.—*Production of Antimony-ore for the years 1914 to 1918.*

—	1914.		1915.		1916.		1917.		1918.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Burma—										
Amherst . .	..	..	13·5	*231*	1,000	*500*	105	*52*	..	..
Punjab—										
Jhelum . .	(a)	*4*	(b)	*5*	(c)	*3*	(d)	*2*	(e)	*1*
Mysore—										
Chitaldrug .	..	..	..	..	40	(f)	25·5	*85*	·1	*5*
TOTAL .	..	*4*	13·5	*236*	1,040	*503*	130·5	*139*	·1	*6*

(a) 6·17 lbs. (b) 2·06 lbs. (c) 4·11 lbs. (d) 2·58 lbs. (e) 1·4 lbs. (f) Value not returned.

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234 (1906).
[2] G. H. Tipper, *ibid*, XXXV, p. 51 (1907).
[3] L. L. Fermor, *ibid*, XXXIII, p. 62 (1906).

Antimony is used chiefly for hardening alloys, for match manufacture and the vulcanising of rubber in the form of sulphide, and calico-dyeing and calico-printing in the form of tartrate and oxalate.

Arsenic.

[E. H. PASCOE.]

Occurrence.

The chief indigenous source of arsenic is the orpiment mines of Chitral, where the mineral is exploited by the Mehtar of that country. The output of these, however, has latterly fallen off considerably, being under 10 tons in 1905-06; and no returns are available for recent years, although the industry is still carried on. A seam of arsenopyrite 1 foot thick, of which about two-thirds consist of ore, is recorded from the northern flank of Sampthar Hill near Darjeeling. A small outcrop of the same mineral is known to occur near Barali in the Bhutna valley, Kashmir. The occurrence of orpiment near Munsiari in Kumaon has long been known,[1] small quantities of this mineral and of realgar, the other sulphide, being sold in the bazars of northern India; but it was not till 1906, when Messrs. G. de P. Cotter and J. Coggin Brown found scattered fragments of both minerals lying on the moraine material of the Shankalpa glacier, that any precise locality was ascertained. The ore was not found *in situ*, but had probably come from the hill face immediately above.[2] Large lumps of leucopyrite, an arsenide of iron, have been found in the pegmatites of the mica-mining field near Gawan in the Hazaribagh district,[3] and other arsenides have been found associated with pyritous lodes in various places, but no attempt has been made to recover arsenic from these occurrences. Two species of arsenates have been found in India, one (tilasite) in the Kajlidongri manganese mine, Jhabua State, Central India, and the other (fermorite) in the Sitapar manganese mine, Chhindwara district, Central Provinces,[4] but they have not proved to be of economic importance.

Exports and Imports.

Details with regard to the production and use of Indian arsenic are not available, but there has been a considerable trade in both Indian and foreign arsenic, presumably in the form of white arsenic.

[1] A. W. Lawder, *Rec. Geol. Surv. Ind.*, II, p. 88 (1869).
[2] *Ibid*, XXXVI, p. 129 (1908).
[3] T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 51 (1902).
[4] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 218—219 (1909); and G. F. Herbert Smith and G. T. Prior, *Mineralogical Mag.*, XVI, pp. 84—96 (1911).

Table 111 shows the extent of this trade for the period under review, but does not include the trade in orpiment, which is shown separately. By comparison with the corresponding tables of previous reviews it will be seen that the annual imports of foreign arsenic remained remarkably constant up to the period under consideration (2,346 tons for 1898-1903; 2,370 tons for 1904-08; and 2,596 tons for 1909-13). During 1914-18 the figure has fallen to 1,558 tons.

TABLE 111.—*Average Annual Exports and Imports of Arsenic (excepting Orpiment) for the years 1914-15 to 1918-19.*

—	Quantity.	*Value.*
	Cwts.	
Exports of Indian Arsenic (except Orpiment)—		
To Straits Settlements	70	
,, Other countries	7	
TOTAL .	77	£171
Imports of Foreign Arsenic (except Orpiment)—		
From United Kingdom	430	
,, China (with Hongkong)	667	
,, Straits Settlements	61	
,, Other countries	400	
TOTAL .	1,558	£3,038
Re-export of Foreign Arsenic (except Orpiment) . . .	*21*	*£51*

Chinese orpiment. Orpiment, the yellow sulphide of arsenic, is largely imported into Burma from Western China for use mainly as a pigment. During the five years 1914-15 to 1918-19 the average annual imports across this frontier amounted to 3,731 cwts. valued at £5,167, or 27 shillings and 9 pence per cwt. (see table 112) as compared with 6,243 cwts. valued at £7,809, or 25 shillings per cwt. during the five years 1909-10 to 1913-14.

The mineral is used as a pigment in the manufacture of Indian ornamental lac-wares and the Burmese lacquer-work, in which the favourite greens of the Pagan workers are produced by mixtures of

indigo and orpiment, and the so-called gold-lacquer of Prome by powdered orpiment and gum. It is used also for the designs on the Afridi wax-cloths.

Table 112.—*Imports of Orpiment from Western China.*

Year.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1914-15	1,142	*1,180*	20·66
1915-16	3,404	*4,120*	24·21
1916-17	9,633	*14,357*	29·81
1917-18	2,953	*4,224*	28·61
1918-19	1,521	*1,953*	25·68
Average .	3,731	*5,167*	27·79

Asbestos.

[E. H. Pascoe.]

Attempts to develope asbestos in India have not yet met with any marked success on account of the inferior quality of the material in the deposits hitherto discovered. In 1910, 3 tons of asbestos valued at £6 were extracted in the Bhandara district, Central Provinces, presumably during prospecting operations; this source has recently been given a fresh trial, yielding 7 tons in 1917 and 13 tons in 1918. In 1913 a small amount of work was carried out in the Hassan district, Mysore, where asbestos of fair quality is found in veins traversing actinolite schist, and the supply rose to 344 tons in 1918. Several fresh occurrences were discovered during the period 1909-1913, of which two appeared to be of some size. One of these, near Dev Mori in Idar State, Bombay Presidency,[1] contains a considerable amount of amphibole-asbestos in large rod-like masses yielding long-staple asbestos up to 8 inches; hopes were at first entertained of this product but unfortunately it has proved to be too brittle.

[1] C. S. Middlemiss, *Rec. Geol. Surv. Ind.*, XLII, pp. 53, 73 (1912).

The other occurrence is in the Seraikela State, Singhbhum, the asbestos being of the amphibole variety, obtainable in long columnar masses, the more superficial portions suffering from the same defect of brittleness; recently, however, it has been found that the quality improves with depth, and hopes are entertained that this may prove to be the case in other localities also.

TABLE 113.—*Production of Asbestos for the years 1914 to 1918.*

—	1914.		1915.		1916.		1917.		1918.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Central Provinces—										
Bhandara .	..	..	..	..	..	..	7	*36*	13	*74*
Mysore—										
Hassan . .	5	*23*	..	..	5	*22*	141	*267*	344	*891*
TOTAL .	5	23	..	..	5	22	148	303	357	965

Barytes.

[H. H. HAYDEN.]

Barytes, or heavy-spar, has many applications in the arts, such as giving weight to paper, body to paints, and as a flux in metallurgy (particularly for ferro-manganese). It seems to be widely distributed throughout the Indian Empire, but has only in recent years been seriously exploited. At Sleemanabad in the Jubbulpore district, one of the copper lodes is rich in barytes, which, however, is said to be of poor quality.[1] It occurs in considerable quantities at Balpalpalle and other localities near Betamcharla in the Karnul district, Madras, and has been quarried for use in paint works in this country. The output in 1918 was 2,724 tons valued at £2,948.

Amongst other known occurrences of barytes in India, the following may be mentioned :—

(1) Narravada, Nellore district, Madras: barytes veins in mica schist, into which they pass in places.[2]

(2) Bawdwin silver-lead mines, Northern Shan States: in considerable quantity at one spot.[3]

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 62 (1906).
[2] H. C. Jones, *ibid.*, XXXVI, p. 233 (1908).
[3] T. D. LaTouche and J. C. Brown, *ibid.*, XXXVII, p. 255 (1909).

(3) Taung-gaung, Mandalay district, Burma: a bed of barytes 6 to 7 feet thick.[1]

(4) Kelat and Las Bela States, Baluchistan: fairly abundant in the Belemnite shales; the most accessible locality is Pabni Chauki, about two days' march from Karachi.[2] Barytes has also been found in the Middle Khirthar shales.

(5) Alangayam, Salem district, Madras, where certain gneisses are traversed by a plexus of quartz-barytes veins.[3]

Borax.

[H. H. HAYDEN.]

No undoubted occurrence of borax is known within British Indian territory, and the material exported, which during the last five years has averaged annually 5,176 cwts., of a value of £9,362 (table 114), is practically all obtained from Tibet and Ladakh, being imported across the frontier into the Punjab and United Provinces. The word *tincal*, by which it is known in the bazars, is in common use on the Punjab frontier, where one meets, in the Himalayan passes, herds of goats and sheep coming down in the spring from Tibet, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

TABLE 114.—*Exports of Borax by sea from India during the years 1914-15 to 1918-19.*

—	QUANTITY.		*Value.*	Value per cwt.
	Cwts.	*Metric. Tons.*		
			£	Shillings.
1914-15	4,461	*227*	6,191	27·76
1915-16	6,252	*318*	10,010	32·02
1916-17	7,353	*373*	14,102	38·36
1917-18	2,873	*146*	5,875	40·09
1918-19	4,939	*251*	10,634	43·06
Average	*5,176*	*263*	*9,362*	*36·17*

[1] H. H. Hayden, MS. notes (1896).
[2] G. H. Tipper, *Rec., Geol. Surv. Ind.*, XXXVIII, p. 214 (1909).
[3] T. H. Holland, *ibid.*, XXX, p. 236 (1897).

In addition to the borax sent by sea to foreign countries, small quantities cross the frontier into Nepal, Kashmir, Kelat, Afghanistan, Tibet and China. Of late years the export trade in borax has very seriously declined. Thirty years ago the quantity sent out of India amounted to over 16,000 cwts. a year, valued at £24,000. At that time the greater part of the material exported went to the United Kingdom (14,134 cwts. in 1883-84), but, with the discovery of large deposits of calcium borate in America, the demand for borax from India ceased, and, under normal conditions, the only large customers are now the Straits Settlements and China.

The amount of borax imported into India across the frontier has averaged (as shown in table 115) 21,723 cwts. of the value of £28,720, as compared with an average annual figure of 20,885 cwts. valued at £20,974 for the period of the preceding review; whilst the amount imported by sea has averaged (as shown in table 116) 7,742 cwts. of the value of £13,542 as compared with 5,325 cwts. of the value of £5,044 during the period 1909 to 1913. Adding the land and sea imports, it is seen that there has been a substantial increase in the consumption of borax in India from 21,825 cwts. per annum during the period 1909-13 to 29,465 cwts. per annum during the period under review.

TABLE 115.—*Imports of Borax by land during the years 1914-15 to 1918-19.*

YEAR.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1914-15	14,427	*9,401*	13·03
1915-16	17,884	*13,297*	14·87
1916-17	25,004	*27,750*	22·19
1917-18	25,644	*46,518*	36·28
1918-19	25,657	46,636	36·35
Average .	*21,723*	*28,720*	*26·44*

TABLE 116.—*Imports of Borax by sea during the years 1914-15 to 1918-19.*

Year.	Quantity.	*Value.*	Value per cwt.
	Cwts.	£	Shillings.
1914-15	6,301	*6,907*	21·92
1915-16	8,275	*11,880*	28·71
1916-17	7,225	*13,647*	37·78
1917-18	9,378	*21,158*	45·12
1918-19	7,530	*14,116*	37·49
Average	*7,742*	*13,542*	*34·98*

Of the amounts brought across the frontier, and shown in table 115 to have an annual average of 21,723 cwts., 286 cwts. came from Central Asia, and 4 cwts. from Nepal; the rest came from Tibet.

The borax obtained in the Puga valley of Ladakh, Kashmir, is deposited from hot springs associated with sulphur deposits, which probably represent the final phase of declining volcanic action. The material collected in Tibet is obtained from salt lakes, which have possibly obtained their borax in a similar way from hypogene sources. In other parts of the world, as in California, Argentina, Bolivia, and Chile, deposits of calcium borate, colemanite, are worked for their boracic acid, besides the borax of salt lakes and marsh deposits. In Italy borax is obtained from volcanic fumaroles.

Building Materials.

[E. H. Pascoe.]

As remarked by Sir Thomas Holland, "if the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country. The attempt made to obtain returns of building stones, road metal, and clays used in India was abandoned when it was shown, in 1899, that the returns could not possibly rank in value much above mere guesses."

In the absence of statistics, it is difficult to express shortly the trade in a material so widespread as common building stone. There are, however, a few features which are specially developed in, if not peculiar to, India. In the southern part of the Peninsula, various igneous rocks—the charnockite series near Madras, and the gneissose granites of North Arcot and Mysore—are largely used; in the centre, slates and limestones from the Cuddapah series, and basalt from the Deccan trap-flows are quarried. In Central India, the Central and United Provinces, the great Vindhyan system provides incomparable sandstones and limestones, while in Bengal and the Central Provinces the Gondwana sandstones are used on and near the coalfields. In the Narbada valley the so-called coralline limestone of the Bagh series forms an excellent building stone with a certain claim to inclusion in the ornamental class. Among the younger rocks the nummulitic limestones in the north-west and in Assam are largely quarried, while the foraminiferal Porbandar stone in Kathiawar is extensively used in Bombay and Karachi.[1]

The abundant development of concretionary carbonate of lime in the great alluvial plains, and the extensive development of laterite on the Peninsula and in Burma are dependent, in their more pronounced forms, on conditions peculiar to tropical climates, and these two substances, the so-called *kankar* and laterite, are about the most valuable assets in building material possessed by the country.

The three great physical divisions of India, being the result of three distinct geological histories, show general contrasts in the materials available for simple as well as ornamental building purposes. In the great alluvial plains buildings of importance are usually made of brick, but the surrounding tracts furnish a supply of stone, which is steadily increasing with improved facilities for transport. The monotonous line of brick and stucco buildings in Calcutta is being relieved by the introduction of Vindhyan sandstones from Mirzapur and the calcareous freestones and buff traps brought from the western coast. But the use of Italian marbles, mainly for floorings and, in a smaller way, the introduction of polished granite columns and blocks from Aberdeen and Peterhead, have continued, mainly

Imports.

[1] A 'Memoir on the Economic Geology of Navanagar State' by G. E. Howard Adye (1914), deals with the economic uses of the miliolite limestones, Deccan Trap rocks, both acid and basic, and the laterite of this State.

because these materials, which are no better than, and possibly on the whole inferior to, those of Indian origin, are placed on the market at cheap rates and in a manner suitable to the immediate requirements of the builder and architect.

During the five years 1914-15 to 1918-19 the value of building and engineering materials imported from foreign countries into India has had an average annual value of £692,414, exclusive of stone and marble, which have averaged £29,141 annually during the same period. The substances included in the trade statistics under the heading of building materials and entered into the above total comprise asphalt, bricks and tiles, cement, chalk and lime, clay and earthenware piping. The values of some of these are given in the section on clays. The quantity of cement imported annually, during the five years 1914-15 to 1918-19, has averaged 103,701 tons valued at £449,442; and the annual imports of chalk and lime during the same period have averaged £2,182 tons valued at £7,217.

Ornamental building stone.

As Sir Thomas Holland has remarked,[1] " it is naturally surprising to find that a country which owes its reputation for architectural monuments as much to the fact that it possesses an unlimited supply of ornamental building stone as to the genius of its people is dependent on foreign supplies to the extent indicated by these import returns. It can hardly be an accident that each dynasty which has existed in India since the wonderful Buddhist topes of Sanchi and Bharhut were erected, has been marked by the erection of great monuments in stone, and there can be little doubt that the abundance of suitable material has been an important contributory cause in the growth of India's reputation for architecture."

Besides the architectural remains left by the Buddhists, there are famous works in stone by the Hindus of the eighth to tenth centuries, including the great Dravidian temples of Southern India, mostly built of granites and other crystalline rocks, and the richly ornamented buildings of Orissa and of Chanda built of Gondwana sandstones. The Pathans and Moghals utilised both the Vindhyan sandstones of Central India and the beds of marble in Rajputana for building their magnificent mosques, palaces and tombs in the cities of Northern India. It is only necessary to mention here

[1] *Rec. Geol. Surv. Ind.*, XXXII, p. 103.

Akbar's city of Fatehpur Sikri, where the red and mottled sandstone of the Bhander series was used, and the famous Taj, built mainly of white Makrana marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and blood-stones from the Deccan trap, and red jasper from the Gwalior (Bijawar) series.

The delicate and intricate carvings, for which some varieties of the Indian sandstone are so well suited, are admirably shown in an 'Illustrated Catalogue of Ornamental Carved Stone in Gwalior,' published by the Department of Commerce and Industry, Gwalior, in 1912.

Although, in most cases, reliable statistics concerning the production of building stones in India are not obtainable, yet we give here such figures as are available, excluding those relating to marble and slate, which are treated in separate sections.

Granite and gneiss.

Gneissose granites and gneisses are used as building stones and for road-metal in many parts of Peninsular India, particularly in the Madras Presidency, for which returns have been available since 1910. Figures of production and value for Bihar and Orissa, Burma, and Madras are given in table 117.

From 1907 to 1908 there was a sudden increase in the Burmese production of granite and gneiss, from 27,781 tons to 340,939 tons. This was largely due to the development of quarries in gneissose granite in the Thaton district for the supply of stone to the Burma Railways Company and the Town Lands Reclamation Works in Rangoon. Owing probably to the same causes the production of the Thaton quarries is reported to have reached the enormous figure of 7,642,268 tons in 1909, valued at £344,704.[1] Since then the production from this district has been relatively small, but in 1909 quarrying began at Kalagauk Island in the Amherst district in connection with the Rangoon River Training scheme. The output in 1909 was 57,500 tons which, with the introduction of a regular service of hopper barges, reached a total of 295,125 tons in 1912. With the completion of the scheme the works were closed down in 1914. During the present period there has been a steady rise up to 1917 and a somewhat sharp fall of 72,000 tons in

[1] The Government of Burma were unable to confirm this figure owing to the destruction of the district records.

1918 from Burma. The figures for Madras show capricious fluctuation reaching 305,131 tons in 1916. Too much significance must not be placed on these figures, which are probably largely affected by the periodical demand for road-metal for the town of Madras.

Sandstone.

The available figures for the production of sandstone in India are shown in table 118. Those shown for the United Provinces refer to the output of Upper Vindhyan sandstone from the quarries at Chunar in the Mirzapur district, which has averaged 75,762 tons a year, valued at £9,182, less than half that of the previous quinquennium. The figures for Bihar and Orissa refer chiefly to the output of Vindhyan and Gondwana sandstones, from the districts of Shahabad and Manbhum respectively. A quartzite of good quality from Susunia Hill, Bankura, has been largely employed in Calcutta for paving and curb stones. In Burma, sandstone is quarried in many districts, amongst which may be mentioned the Northern Shan States, Meiktila, Thaton, Minbu, Kyaukse, Pakokku, Amherst, Shwebo, and Akyab.

Limestone.

The subject of building materials naturally includes limestone used as a building stone, and the two derived products—lime and cement; these are obtained, obviously, from the most conveniently situated deposits of limestones, such as those of the Upper Vindhyan series worked near Sutna in the Rewah State by the Sutna Stone and Lime Company, Ltd.; those of the Lower Vindhyan series worked at Katni in the Jubbulpore district by Messrs. Cook & Sons and others; those worked in the Cuddapah series at Bisra and Rourkela in Gangpur State by the Bisra Stone Lime Company; or the various bands of crystalline limestones in Madras, Central India, and Rajputana, and the nummulitic limestones of Assam. The last-mentioned stone is brought down by boat during the rains from the southern scarp of the Khasi and Jaintia Hills to Sylhet where it is burnt in primitive kilns; Calcutta at one time derived its main supply of building lime from this source. Vast quantities of limestone suitable for building-stone or for lime-burning, are available over large areas of Baluchistan. Such figures as are available for the production of limestone during the period under review are given in table 119. The production of the Sutna Stone and Lime Company in Rewah may be gauged from the quantities despatched from the works during the five years 1914 to 1918. The quantity of limestone has averaged annually 44,503 tons valued at £2,967,

TABLE 117.—*Production of Granite and Gneiss during the years 1914 to 1918.*

Province.	1914.		1915.		1916.		1917.		1918.		Average.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa . .	4,713	*937*	1,617	*160*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*	3,165[1]	*548*[1]
Burma	108,711	*8,506*	122,173	*10,675*	219,153	*18,388*	255,290	*18,730*	182,892	*15,760*	177,644	*14,412*
Madras	76,226	*1,465*	94,618	*2,784*	305,131	*4,927*	58,878	*2,466*	116,296	*4,518*	130,230	*3,232*
TOTAL .	**189,650**	*10,908*	**218,408**	*13,619*	**524,284**	*23,315*	**314,168**	*21,196*	**299,188**	*20,278*	**311,039**	*18,192*

[1] Average of 2 years.

TABLE 118.—*Production of Sandstone during the years 1914 to 1918.*

PROVINCES.	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa . .	28,014	*2,221*	21,092	*1,317*	57,098	*1,877*	70,166	*2,249*	97,134	*2,955*	54,701	*2,124*
Burma	163,246	*7,420*	51,539	*4,022*	57,480	*5,541*	86,636	*6,195*	79,166	*4,247*	87,613	*5,485*
Hyderabad . . .	(a)	*7*	(a)	*4*	(a)	*4*	(a)	*10*	(a)	*17*	..	*8*
Punjab . . .	60,818	*6,371*	38,215	*3,051*	137,579	*8,118*	109,432	*7,269*	27,613	*1,563*	74,731	*5,274*
Rajputana . . .	39,292	*12,577*	39,781	*13,315*	40,574	*11,765*	38,894	*11,479*	33,937	*11,478*	38,496	*12,123*
United Provinces . .	197,699	*21,907*	166,185	*18,471*	3,927	*1,233*	5,000	*1,500*	6,000	*2,800*	75,762	*9,182*
TOTAL .	489,069	*50,503*	316,812	*40,180*	296,658	*28,538*	310,128	*28,702*	243,850	*23,060*	331,308	*34,196*

(a) Quantity not reported.

During the period under review unslaked lime has averged 15,814 tons valued at £7,980; the slaked lime has averaged 3,053 tons valued at £569; and the stone setts have averaged 69,306 pieces valued at £353. As is shown by these figures, much of the limestone is not converted to lime; it is instead railed a distance of 530 miles to the Barakar Iron Works, where it is used as a flux in the blast furnaces.

The Maihar Stone and Lime Company, Ltd., has produced an average annual amount of 7,538 tons of Vindhyan limestone valued at £138 during the five years 1914-18, from quarries in the Maihar State, Central India; this is less than half what it was during the previous five years. There is also a small annual production of limestone in Gwalior State, both kankar and Bhander (Vindhyan) limestone being used.

The production from Bihar and Orissa is derived chiefly from Gangpur State with; in some years, large amounts of kankar and limestone from the Shahabad district. The Gangpur output includes the production of the Bisra Stone Lime Company which has averaged 46,729 tons valued at £6,262 (2 rupees a ton) for the five years 1914 to 1918. The following amounts of dolomite from Panposh, used as a flux in their works at Sakchi, were produced by the Tata Iron and Steel Company, the average being 102,396 tons valued at £13,652 (2 rupees a ton):—

	Tons.
1914	97,266
1915	97,343
1916	84,632
1917	108,710
1918	124,031
TOTAL	511,982

Towards the end of the quinquennium 1909-13 the opening of the Dehri-Rohtas Light Railway led to the formation of three companies—The Kalianpur Lime Works, Ltd., The Kuchwar Lime and Stone Company, Ltd., and The Sone Stone and Lime Works—to work the Rohtas (Vindhyan) limestone at and near Banjari in the Shahabad district. The lime produced is said to be of good quality, and consequently the output of limestone in this district may be expected to increase in the future.

The production shown for the Central Provinces refers, with the exception of a trivial output from the Hoshangabad district, entirely

to Katni, where the limestone quarries come under the control of the Indian Mines Act. The quantity raised under this Act has varied from 146,055 tons in 1914 to 44,905 tons in 1916, the average for the quinquennium being 92,359 tons worth £7,611. The average daily labour employed is shown below separately for each year, the average for the period being 2,176 persons. The number of deaths has been 1 giving an average death-rate of 0·09 per 1,000.

Production of Limestone from Katni Act Mines and labour statistics.

—	Quantity.	*Value.*	Persons employed daily.
	Tons.	£	
1914	146,055	*11,902*	3,824
1915	63,079	*5,201*	1,847
1916	44,905	*3,441*	1,525
1917	82,340	*6,608*	1,797
1918	125,417	*10,902*	1,886
Average .	*92,359*	*7,611*	*2,176*

A very small proportion of the limestone, shown as quarried in Assam, comes from the Lakhimpur district and Manipur, practically the whole of the output being from the Khasi and Jaintia Hills, where the nummulitic limestone is being worked by the Sylhet Lime Company, Ltd. The output from this province has varied from 108,431 tons in 1914 to 57,100 tons in 1917, the average quantity being 83,124 tons worth £6,104.

As regards the other areas reported as producing limestone, that in Baluchistan comes from the Las Bela State; the limestone of Burma comes from many districts, the most important of which are Mandalay, Kyaukse, Southern Shan States, Northern Shan States, and Meiktila; a large proportion of the Madras production comes from the Cuddapah district. The small production reported from the Punjab comes from the Jhelum, Hoshiarpur and Ambala districts, whilst the output reported from Rajputana comes chiefly from Alwar and Sirohi. The small production reported from the United Provinces comes from the Naini Tal, Almora, Garhwal, and Dehra Dun districts.

Kankar. One of the most widespread and interesting sources of lime is the material generally known by the name of *kankar*, some of the more solid varieties of which have found a limited use as building-stone. The commonest mode of occurrence is in the great alluvial deposits, particularly in the older alluvium, in which the calcareous substances have segregated from the rest of the materials and have grown into irregular lumps like flints in chalk, including in the concretions a certain amount of the argillaceous substances, which, when the *kankar* is burnt, is present in a proportion not far removed from that necessary to produce a hydraulic lime. The material of these concretions constitutes, in fact, a "natural cement."

Another industry for which it is hoped a high grade limestone will be in increasing demand is the manufacture of calcium carbide and calcium cyanamide. The latter is becoming increasingly important as a nitrogenous manure and a greater supply would in all probability create its own demand.

Laterite. The curious superficial rock known as laterite is widely distributed over the whole of the Peninsula of India and in Burma. In certain cases it has a special value as an ore of aluminium (see page 252), iron, or manganese, according to composition (see page 192), but it is also very widely used as road-metal and as a building stone for culverts and buildings; for the latter purpose it possesses one advantage over other stones in the ease with which it can be cut into blocks and its power of subsequently hardening when exposed to the air. In most cases, no statistics are collected. In table 120 are given the statistics for Bihar and Orissa, Burma, Central Provinces and Madras. The figures for Bihar and Orissa relate to the Puri and Singhbhum districts, the latter yielding 36,500 tons in 1916 and the same quantity in 1917. The annual Burmese output during the period averaged 223,318 tons valued at £16,904, giving an average value of 1*s*. 6*d*. per ton. The output comes from some twenty districts, but by far the most important are Hanthawaddy with an average annual output during the period of 47,217 tons, Insein with 40,811 tons, and Thaton with 66,799 tons, all of which districts lie in the Irrawadi valley. The laterite of Madras comes from 8 coastal districts, of which Chingleput (annual average of 64,751 tons for the period) and Malabar (33,298 tons) contribute by far the larger portion. Some 16,500 tons were obtained in Balaghat in 1915.

TABLE 119.—*Production of Limestone and Kankar during the years 1914 to 1918.*

—	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Assam (*a*)	108,431	*9,418*	103,736	*6,395*	87,425	*5,609*	57,100	*5,178*	58,928	*3,920*	83,124	*6,104*
Baluchistan	212	*395*	..	..	..	..	..	..	..	..	42	(*d*) *79*
Bihar and Orissa	239,297	*24,061*	242,364	*35,245*	288,040	*34,898*	264,966	*69,039*	335,627	*49,256*	274,059	*42,500*
Bombay	..	..	9,080	*333*	5,000	*100*	1,192	*100*	..	..	3,054	(*d*) *106*
Burma	185,802	*10,068*	160,498	*7,933*	130,709	*8,134*	174,034	*12,437*	199,222	*15,782*	170,053	*10,871*
Central India (*b*)	36,694	*2,045*	33,715	*1,801*	42,907	*2,519*	69,512	*4,420*	77,493	*4,749*	52,064	*3,107*
Do. (*c*)	17,207	*9,171*	18,973	*1,296*	16,201	*8,626*	17,056	*8,959*	26,183	*14,809*	19,124	*8,573*
Central Provinces	148,471	*12,012*	63,079	*5,201*	45,555	*3,488*	86,444	*6,917*	134,798	*12,479*	95,669	*8,019*
Madras	65,419	*2,547*	11,250	*572*	13,964	*794*	9,541	*551*	6,028	*502*	21,241	*993*
North-West Frontier Province.	16,428	*370*	6,444	*290*	7,037	*317*	2,541	*114*	8,072	*363*	8,105	*291*
Punjab	31,218	*2,178*	28,988	*1,514*	23,492	*1,296*	15,497	*895*	40,046	*1,914*	27,847	*1,559*
Rajputana	5,485	*648*	3,008	*549*	810	*478*	820	*479*	815	*479*	2,188	*527*
United Provinces	615	*150*	408	*56*	38	*5*	3,361	*805*	3,851	*696*	1,655	*342*
TOTAL	**855,279**	*73,063*	**681,543**	*61,185*	**661,178**	*66,264*	**702,064**	*109,894*	**891,063**	*104,949*	**758,225**	*83,071*

(*a*) Derived almost entirely from the Khasi and Jaintia Hills with very small quantities from Lakhimpur and Manipur.
(*b*) Production of Maihar, and the Sutna Stone and Lime Company excluding (*c*).
(*c*) Limestone converted to lime before despatch by the Sutna Stone and Lime Company.
(*d*) Average of 5 years.

TABLE 120.—*Production of Laterite during the years 1914 to 1918.*

PROVINCES.	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa . .	3,067	*41*	2,732	*36*	38,845	*1,248*	38,405	*1,242*	1,629	*35*	16,936	*520*
Burma	166,377	*14,095*	228,124	*20,554*	222,514	*17,199*	286,924	*13,091*	212,649	*19,579*	223,318	*16,904*
Central Provinces . .	..	..	16,445	*876*	..	..	..	..	..	..	3,289	(*a*) *175*
Madras	93,630	*3,035*	94,574	*3,405*	200,696	*5,117*	97,042	*3,905*	110,515	*5,048*	119,291	*4,102*
TOTAL .	**263,074**	*17,171*	**341,875**	*24,871*	**462,055**	*23,564*	**422,371**	*18.238*	**324,793**	*24,662*	**362,834**	*21,701*

(*a*) Average of 5 years.

Gravel.

The mineral returns of Burma regularly give details of the production of gravel in various districts; the total figures are—

1914	77,472 tons valued at	£2,513
1915	81,972 ,, ,, ,,	2,618
1916	88,218 ,, ,, ,,	3,306
1917	85,355 ,, ,, ,,	2,553
1918	93,597 ,, ,, ,,	3,084
Average	*85,323* ,, ,, ,,	*2,815*

The most important districts are Henzada, Mandalay, Lower Chindwin, and Tavoy. The material is used for the repair of roads.

Clays.

[E. H. PASCOE.]

Importance of clay as a mineral product.

The important part played by clay in the industrial development of a country is not generally recognised, but can easily be illustrated by reference to the mineral statistics of such an industrially advanced country as the United Kingdom. From table 2 on page 11 it will be seen that in 1918, clay ranked fourth in value amongst the mineral products of that country; the output in that year was 6,003,345 statute tons valued at £1,696,127. The figures for the United States relate not to the raw material, but to the products manufactured therefrom, and the magnitude of the total value—£51,036,345—can be grasped when it is pointed out that this is more than three times the value of the total Indian mineral output for the same year of all minerals for which statistics are available.

Production in India.

No statistics approaching any degree of completeness are obtainable to show the extent of the undoubtedly great industrial value of the clays in India. They include the common clays, derived largely from the silt of the large rivers and used all over the country for the manufacture of bricks, tiles and the cheaper forms of pottery; finer varieties used for glazed pottery, which in places has obtained a reputation for artistic merit; fire-clays raised in considerable quantities on some of the Gondwana coal-fields; and Fullers' Earth, which is mined in the Central Provinces and in Rajputana.

TABLE 121.—*Production of Clay in India during the years 1914 to 1918.*

Province.	1914.		1915.		1916.		1917.		1918.		Average.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bengal	19,161	*951*	27.235	*1,521*	22,755	*1.210*	11,340	*587*	20,348	*1,159*	20,168	*1,086*
Bihar and Orissa	785	*150*	1,638	*347*	2,588	*1,116*	23,277	*3,740*	33,992	*6,490*	12,456	*2,369*
Burma (a)	978	*180*	629	*132*	423	*85*	10,390	*821*	26.271	*1,429*	7,738	*529*
Central India	1,000	*225*	1,278	*460*	1,800	*648*	3,244	*965*	1,301	*407*	1,724	541
" Provinces	33,738	*1,198*	33,359	*1.280*	39,295	*1,586*	34,091	*2,111*	58,357	*3,240*	39,768	* *1,883*
Delhi	..	..	..	..	..	..	2,203	*128*	2,536	*169*	948	(c) *59*
Madras	78	(b)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	..	..
Mysore	..	..	..	..	..	..	2,200	*667*	1,717	*1,190*	783	(c) *371*
TOTAL	**55,740**	*2,704*	**64,139**	*3,740*	**66.861**	*4,645*	**86,745**	*9,019*	**144,522**	*14,084*	**83,585**	*6,838*

(a) The Government of India, Department of Commerce and Industry, in their letter No. 7358—7369-121, dated the 8th September 1913, informed all the Local Governments that information on ordinary clay or Kankar need not be included in their annual mineral returns and hence the decrease in. and total absence of, figures in this head from Burma and Madras respectively.
(b) Valued at Rs. 5 only.
(c) Average of 5 years.

For Burma fairly complete returns were available up to 1912 stated separately for each district, the most important districts being Yamethin, Myingyan, Henzada, Maubin, Pyapon and Hanthawaddy. For the reason for the smallness of the Burma and Madras figures, see footnote to table 121. The consumption of building bricks in the United Provinces and in Bihar and Orissa probably reaches a high figure.

The output for the five years 1914-18 is summarised in table 121, from which it will be seen that the average annual output has been 83,585 tons valued at £6,838, giving an average value of 1*s.* 8*d.* per ton. These clays are common brick and potters' clays.

The Bengal output is derived from the Burdwan district. That of the Central Provinces is mainly from the Jubbulpore district with a small production from the Hoshangabad district. The main portion of the Jubbulpore output is derived from quarries in the Upper Gondwanas near Jubbulpore town and is used in the pottery works of Messrs. Burn & Co. and of the Perfect Pottery Co. But a certain amount of clay was won by the Katni Cement and Industrial Co. at Tikuria near Katni. The Madras production is derived chiefly from the districts of Ganjam, South Kanara, Ramnad, Tinnevelly and Trichinopoly.

Fullers' Earth is obtained at Katni in the Jubbulpore district of the Central Provinces, where it occurs in the Lower Vindhyan series. A form of Fullers' Earth known as *multani-matti* is also worked in the states of Bikanir and Jaisalmer in Rajputana; this and other varieties are eaten in various parts of India. A steady supply has been derived also from Marwar in Rajputana. The production from Jubbulpore and Marwar during the period under consideration was :—

Production of Fullers' Earth during the years 1914 to 1918.

—	1914.		1915.		1916.		1917.		1918.	
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Central Provinces—Jubbulpore	109	*35*	139	*45*	179	(*a*)	..	..	..	..
Rajputana—Marwar	580	*138*	750	*200*	360	*135*	800	*299*	1,100	*439*
TOTAL	689	*173*	889	*245*	539	*135*	800	*299*	1,100	*439*

(*a*) Not available.

Pottery clays are worked in various parts of India, amongst which may be mentioned Jubbulpore (from the Jubbulpore division of the Gondwanas).

In addition to the common clays used by the native potter in making common earthenware articles by means of the potter's wheel, there are in India many clays of finer quality used in large pottery works, such as those of Jubbulpore and Raniganj, where, however, the chief productions are drain-pipes, roofing and flooring tiles, fire-bricks, etc. There can be little doubt that India possesses also all the materials necessary for the manufacture of porcelain of the highest quality, such materials being found in the Jubbulpore district and the Rajmahal Hills.

The china-clay and fire-clay deposits of the Rajmahal Hills were investigated by Dr. Murray Stuart,[1] who reports most favourably on their suitability for manufacturing porcelain and fire-bricks of the highest quality.

The Calcutta Pottery Works has been using kaolin from Mangal Hat in the latter area and has succeeded in producing cups, saucers, jugs, and ornaments of common white porcelain.

Testing of Indian clays.

Some years ago a series of 95 samples of Indian clays was subjected to a critical examination at the Imperial Institute, and a report on them submitted by Professor W. R. Dunstan. The clays were carefully inspected, and a number of samples typical of the various groups were selected and submitted to complete chemical analysis. The remainder were subjected to working and firing trials with a view to the observation of their plasticity, refractoriness, and the nature of the product obtained on firing, which are the properties on which the commercial and manufacturing value of clays depend.

The series of clays was divided into two groups (1) kaolins and (2) terra-cotta clays, the latter group comprising by far the larger number of the samples.

The *kaolins* examined were usually of inferior quality, and not in a sufficiently good mechanical condition to be suitable for the manufacture of thin wares such as those produced by 'slip' casting, though it is probable that by careful levigation some of them could be rendered suitable for working by this process.

[1] *Rec. Geol. Surv. Ind.*, XXXVIII, pp. 133—148 (1909).

The *terra-cotta* clays are suitable for the manufacture of stoneware, ornamental vases and tiles, and bricks of good quality. The following analyses are given :—

TABLE 122.—*Analyses of Indian clays.*

—	1	2	3	4	5	6
Potash	0·61	0·21	*Nil*	0·24	0·24	0·07
Soda	0·41	0·25	*Nil*	0·72	0·51	0·26
Lime	1·85	0·13	0·26	*Nil*	0·46	0·30
Magnesia	1·32	0·54	1·63	0·48	3·09	*Nil*
Manganous oxide	0·12	...	*Nil*	...	...	...
Ferrous oxide	0·67	0·45	0·58	0·51	4·02	2·38
Ferric oxide	0·66	1·61	1·16		3·47	4·81
Alumina	32·75	24·82	21·06	13·04	20·28	21·22
Titanic oxide	0·51	...	0·35	...	0·61	trace.
Silica	46·31	64·06	69·95	80·15	56·21	61·43
Carbon dioxide	2·02	...	0·02	...	2·05	0·72
Water	12·40	7·70	4·69	4·75	8·86	9·42
	99·63	99·77	99·70	99·89	99·80	100·61

NOTES.—No. 1. Prepared white kaolin ; from N. Arcot, Madras.
No. 2. Soft pale grey kaolin ; from Hoshangabad, Central Provinces.
No. 3. Soft white kaolin with some pinkish material ; from Bangalore, Mysore.
No. 4. White impure kaolin, subjected to levigation before analysis ; from Shillong, Khasi and Jaintia Hills.
No. 5. Prepared grey clay from Bagirhat, Bengal; a good example of a terra-cotta clay.
No. 6. Dark brown clay with red and yellow ochre in large specks ; from Hanthawaddy, Burma.

Of the clays represented by the above analyses, No. 1 was reported to be suitable for the manufacture of good quality earthenware or porcelain ; No. 2 for the same purpose after careful preparation ; No. 3 highly refractory and suited for the manufacture of fire-

brick or earthenware; No. 4 suitable for fire-bricks or to reduce shrinkage when mixed with kaolin; Nos. 5 and 6 suited for the manufacture of terra-cotta ware.

Imports.

The imports of materials coming under this section,—namely, earthenware and porcelain, earthenware piping, bricks and tiles, and clay,—are shown in table 123, from which it will be seen that there has been an increase, during the five years 1914-15 to 1918-19, from £431,830 in 1914-15 to £571,473 in 1918-19, with an average annual value of £471,868 as compared with an average annual value of £462,677 during the preceding five years. As the average value of the exports and re-exports of clay, and clay products during the period has amounted only to £32,394, the total Indian consumption of such products exceeds the internal production by £439,474 indicating considerable scope for the development in the country of industries making use of clay.

TABLE 123.—*Value of Imports into India of Clay and Clay Products during the years 1914-15 to 1918-19.*

YEAR.	Earthenware and porcelain.	Earthenware piping.	Bricks and tiles.	Clay.	Total annual imports.
	£	£	£	£	£
1914-15	298,586	21,241	102,426	9,577	**431,830**
1915-16	316,022	8,157	146,236	10,973	**481,388**
1916-17	326,512	9,895	117,752	9,496	**463,655**
1917-18	258,542	4,792	139,457	8,202	**410,993**
1918-19	367,356	1,910	190,484	11,723	**571,473**
Average	*313,404*	*9,199*	*139,271*	*9,994*	*471,868*

Cobalt.

[E. H. PASCOE.]

Cobaltite, a sulph-arsenide of cobalt, and danaite, a cobaltiferous arsenopyrite, have been found as minute crystals disseminated

amongst the slates of the Aravalli series at Khetri[1] and other places in Rajputana. These ores have been used for the manufacture of various sulphates. The minerals were formerly separated for the production of *sehta,* which is used by the Indian jewellers for producing a cobalt-blue enamel. The sulphide of cobalt, linnæite ($Co_3 S_4$) has been identified in the Geological Survey Laboratory amongst some ores of copper sent a few years ago from Sikkim by Colonel Newcomen. Some years ago specimens of a matte containing 11 per cent. to 14 per cent. of cobalt, the rest being iron and sulphur, were received in the Geological Survey Office, but no details as to the mode of occurrence have ever been received.[2] Small quantities of cobalt and nickel are frequently detected in the Indian manganese-ores; the best sample is the cobaltiferous wad of Olatura in the Kalahandi State, a specimen of which yielded 0·82 per cent. of cobalt oxide (CoO).

Corundum.

[E. H. Pascoe.]

The use of abrasives in manufacturing communities seems to be on the increase, and new forms are being put on the market yearly. Emery formerly served most requirements, until purer forms of corundum were discovered in quantity. The cheaper forms of garnet have long been used to adulterate emery, and members of the spinel family, such as hercynite, have been used inadvertently as such. During the last twenty years carborundum, manufactured by the cheap electrical power developed in America, has come into use, the production of the United States having now reached several thousand tons a year. Two artificial forms of corundum (alundum and aloxite) are being manufactured from bauxite and emery, respectively, at Niagara, and crushed steel is being used to an increasing extent.

Natural corundum has thus many competitors in the market of abrasive materials, and as a large portion of the alumina in igneous magmas is necessarily used up during the processes of consolidation by the silica and bases present, it is theoretically unlikely that the free oxide can exist anywhere in an abundance comparable to the vast quantities of combined alumina in the earth's crust. In most cases the corundum is scattered as isolated crystals through the

[1] *Rec. Geol. Surv. Ind.*, XIV, pp. 190—196 (1887); see also A. M. Heron, *Rec. Geol. Surv. Ind.*, XLIV, p. 19 (1914).

[2] E. J. Jones, *Rec. Geol. Surv. Ind.*, XXII, p. 172 (1889).

rock, and only the most economical devices for its separation can make mining remunerative.

In India, where the use of corundum by the old *saikalgar* (armourer) and lapidary has been known for many generations, the requirements of the country have been met by a few comparatively rich deposits, but it is doubtful if these are worth working for export in the face of the competition referred to above in Europe and America, or will even stand against the importation of cheap abrasives.

There is still, and for many generations has been, a certain trade in Indian corundum, but the returns for production are manifestly incomplete. No workings exist of the kind that could be ordinarily described as mining, but attempts have been made at times to increase the scale of operations at Palakod and Paparapatti in the Salem district, near Hunsur in Mysore, and in South Rewah. Such production figures as are available are summarised in table 124.

Production.

The occurrence near Pipra in Rewah State has been worked during the period by Indian traders of Mirzapur. The production during the five years 1914-18 is shown in table 124.

Corundum is very widely distributed throughout the Mysore State and is said to occur in every district except Shimoga. In 1914 the output came from Kolar, in 1915 from Kolar (76 cwts.) and Tumkur (843 cwts.), and in 1916 from the Mysore district. The average annual production during the quinquennium was 523 cwts. valued at £104, against 2,434 cwts. valued at £487 during 1909-13.

Of the production of corundum recorded from the Madras Presidency, 211 cwts. from Coimbatore and 478 cwts. from Trichinopoly made up the supply for 1914, but throughout the remainder of the period (1915-18) the whole of the output came from South Kanara.

Much of the corundum, which is a regular item of trade in the bazars of cities like Delhi, Agra, and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cowherds, who dispose of it through the village *bania* to the larger dealers of the great cities. Our information as to the mode of occurrence and distribution of the mineral was summarised in a special memoir published by the Geological Survey in 1898.

Khasi Hills.

Corundum (*mawshinrut*) is known to occur at three localities in the Nongstoin State in the North-West Khasi Hills. The localities are too difficult of access

TABLE 124.—*Production of Corundum in India for the five years 1914 to 1918.*

—	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£	Cwts.	£
Assam (Khasi and Jaintia Hills).	..	..	..	..	36,540	*2,555*	41,200	*3,799*	37,920	*3,862*	23,132	(c)*2,043*
Central India (Rewah) (a)	13	*12*	290	*81*	743	*207*	200	*65*	736	*201*	396	*113*
Central Provinces . .	..	..	..	..	..	..	..	..	1,600	*33*	320	(c)*7*
Hyderabad . . .	(b)	*5*	(b)	*4*	(b)	*4*	(b)	*3*	(b)	*2*	..	*4*
Madras	689	*104*	37	*12*	38	*13*	26	*10*	25	*10*	163	*30*
Mysore	1,657	*331*	919	*184*	40	*8*	..	..	..	..	523	(c)*104*
TOTAL .	2,359	452	1,246	*281*	37,361	*2,787*	41,423	*3,877*	40,281	*4,108*	24,534	*2,301*

(a) The value figures are merely royalties obtained by the State.
(b) Quantity not available.
(c) Average of 5 years.

for the exploitation of the mineral on a large scale, but it is worked in small quantities and used all over the Khasi Hills for hones.[1]

Gem varieties of corundum are treated, of course, under 'Gem-stones.'

Canadian corundum.

The chief producers of corundum and emery are Canada, Turkey, and Greece, Canada supplying corundum, and Turkey and Greece emery. The Canadian corundum is found in Ontario in association with nepheline-syenite like that near Kangayam in the Coimbatore district.[2] By the adoption of mechanical means for concentration it has become possible to separate corundum from the felspar-rock in which it is embedded, and to put a product on the market, not only for local use, but for export to the United States and Europe.

The Canadian industry commenced in 1900, and the annual production for the last five years has averaged 240 tons valued at £6,876, an output which is less than one-sixth of what it was before the war.

Fluor-spar.

[E. H. PASCOE.]

Fluor-spar has been obtained at Barla in the Kishengarh State, Rajputana, but the work of excavation was abandoned under a mistaken impression that the mineral was an inferior form of amethyst. Apparently the mineral forms with calcite and quartz a vein about a foot in thickness traversing gneiss. This occurrence was investigated by the Tata Iron and Steel Co., who report that very little fluor-spar was present, and that the cost of working it would exceed that at which they are able to purchase it from Europe; their imports of fluor-spar annually for use as a flux in the manufacture of steel were as follows:—

	Tons.	Cwts.
1914	366	12
1915	248	17
1916	310	13
1917	190	10
1918	609	10
TOTAL	1,726	2

[1] F. E. Jackson, *Rec. Geol. Surv. Ind.*, XXXVI, p. 323 (1908).
[2] T. H. Holland, 'The Sivamalai series of Elæolite- and Corundum-Syenites,' *Mem. Geol. Surv. Ind.*, XXX, pt. 3 (1901).

Fluor-spar has also been found as small crystals in a dyke of quartz-porphyry near the copper-ore lodes of Sleemanabad, Jubbulpore district[1]; another occurrence in the Central Provinces is known at Chicholi in the Drug district, where it accompanies galena and copper carbonate in a quartz vein traversing gneiss.[2] Other localities recorded for the mineral are near Rewah[3] in one of the Vindhyan limestones; in the granitic veins of the Sutlej valley, North-West Himalayas[4]; and in limestone in the Amherst district, Burma. No indication of large deposits has been noticed at any of the localities.

Gem-stones.

[E. H. PASCOE.]

The most valuable of the precious stones raised in India is undoubtedly the ruby, but this and the other stones obtained in the country do not approach in value the unset stones and pearls imported, which, during the period under review, had an average annual value of £312,234 (compared with £623,130 during the previous quinquennium).

Of the precious and semi-precious stones in India, the most important, amber, diamond, jadeite, ruby, sapphire, and spinel, have been already referred to. Of the others, the only ones that are of immediate concern are agate, rock-crystal, beryl, garnet, tourmaline, and turquoise. All of these except the last have been or are still being worked to some extent in India, and the turquoise may be dismissed with the mere mention of the fact that India, besides being a large importer for local use, is one of the channels by which the material raised in Persia and adjoining areas reaches the European and Eastern market. The other minerals—with some other Indian stones at present used very little or not at all—deserve more particular mention.

Agate.

There is still a considerable trade in agate and the related forms of silica, carnelian, onyx, etc., known under the general name of *hakik*, and obtained from the amygdaloidal flows of the Deccan Trap. The best known and

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 63 (1906).
[2] W. T. Blanford, *Rec. Geol. Surv. Ind.*, III, p. 44 (1870).
[3] F. R. Mallet, *Mem. Geol. Surv. Ind.*, VII, p. 122 (1871).
[4] F. R. Mallet, *Mem. Geol. Surv. Ind.*, V, p. 166 (1866).

perhaps still the most important of the places at which agate and carnelians are cut and prepared for the market is Cambay, the chief city of the State of that name under the Kaira Political Agency, Bombay Presidency. The agates come from various states and districts on or near the edge of the trap, the chief sources of supply being the Kistna, Godavari, Bhima, Narbada and other rivers draining trap-covered areas. A large proportion of the pebbles comes from the State of Rajpipla. An account of the Rajpipla agate industry has been given recently by Mr. P. N. Bose.[1] The agates occur in a conglomerate of probably Pliocene age, and have been worked chiefly at Ratanpur and Damlai. The stones are chipped at the mines, and those approved of taken to Limodra, where they are baked. The baked stones are sent to Cambay for cutting and polishing. The Rajpipla *hakik* mines are leased for periods of five years at a fixed annual rental or royalty. This was Rs. 3,000 a year for the period 1902-06. No precise data as to the value of the stones sent to Cambay are available. The production from the Rajpipla mines from 1914 to 1918 was :—

—	Quantity.	*Value.*
Bombay (Rajpipla State)—	Tons.	£
1914	101	*175*
1915	508	*1,019*
1916	143	*783*
1917	120	*255*
1918	(*a*)	...
TOTAL .	872	2,232

(*a*) Mines were not worked during 1918.

A certain amount of agate-cutting is also carried on at Jubbulpore in the Central Provinces, at Banda in the United Provinces, and at a few other places within range of the Deccan Trap.

Much of the agate retailed in Europe is sent from Cambay, and large quantities are also exported to China.

[1] *Rec. Geol. Surv. Ind.*, XXXVII, pp. 176—182 (1908).

Various forms of quartz—rock-crystal, amethyst, etc.,—are used by jewellers in various parts of India.

Rock-crystal.

In the Tanjore district, Madras Presidency, fragments of rock-crystal are collected and cut for cheap jewellery, being known as 'Vallum diamonds,' whilst the bipyramidal quartz-crystals, found in the gypsum of the salt-marl near Kalabagh and Mari, on the Indus, are to a certain extent used for making necklaces; these crystals are sometimes known as 'Mari diamonds.' Rock-crystal is similarly used for cheap jewellery in Kashmir; an output of 1·5 cwt. valued at £7 was reported from the Skardu Tehsil in 1915. Fine pieces of rock-crystal are sometimes cut into cups, sword handles, and sacred objects, such as *lingams*, in Northern India.

Amethyst and rose-quartz.

Small amethysts, usually of uneven colour, are obtained at many places from Deccan Trap geodes, *e.g.*, in the bed of the Narbada near Jubbulpore, and used for jewellery and beads. Amethyst is common in the Sutlej valley in Bashahr, Punjab,[1] Rose-quartz is found in the Chhindwara district, at Warangal in Hyderabad and in other places[2]; it is used in cheap jewellery.

Apatite.

Green apatite derived from pegmatites in Ajmer in Rajputana is sometimes cut into gem-stones, and a considerable quantity of apatite of a rich sea-green has been found at Devada, Vizagapatam district, Madras, probably from a pegmatitic variety of kodurite.[3] Crystals of a beautiful blue colour are occasionally found in the gravels of the Mogôk Ruby mines.

Beryl.

Beryl in its pale-coloured varieties is of common occurrence in the granite-pegmatites of India, but the crystals are generally too much fissured for use as gem-stones. Occasionally in the pegmatite veins which are worked for mica in Bihar and in Nellore, large crystals of beryl, many inches across, are found to include clear fragments which might be cut as aquamarines; but the only places in India where attempts have been made to excavate pegmatite solely for its aquamarines are at Padyur (Pattalai) near Kangayam, Coimbatore district, where they accompany the mineral cleveclandite, at different places in the Toda

[1] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102 (1904).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 212 (1909).
[3] *Op. cit.*, p. 206.

hills in Rajputana, and in the Skardu Tehsil of Kashmir. Stones of considerable value were obtained from the mine which was worked at Padyur in the early part of the nineteenth century: a pit some 30—40 feet in depth is still in existence, but no one seems to have taken an interest in the place since J. M. Heath held a lease in 1818. The whole area is impregnated with igneous intrusions, and deserves more attention than it has so far received.

At Sagar near Sarwar in the Kishangarh State, Rajputana, aquamarines occur in mica-bearing pegmatites.

The occurrences in Kashmir have proved to be of considerable importance and a paper by Messrs. C. S. Middlemiss and Lala Joti Parshad has already appeared in the Records of this department.[1] The principal source of the stones is the immediate neighbourhood of Daso village, but evidence has been obtained to shew that beryls and aquamarines occur further away up the Braldu and Basha valleys and also in the Rondu neighbourhood. The gems are found in veins of coarse pegmatite traversing foliated biotite-gneiss. They do not, as a rule, shew great depth of colour, but the tint is delicate and limpid. In 1915 3·75 cwts. of beryl of varying quality were obtained in Skardu; the total value is not known but Calcutta and Lucknow jewellers offered from one to four annas a *rati* for clear transparent crystals. In 1916 the supply increased to 4·13 cwts. In the dull state of the market for precious and semi-precious stones it was impossible to form any precise idea of the value of this yield, but it was said to be several thousands of rupees; transparent varieties fetched from 2½ to 4 annas a *rati*. In 1917 a test experiment with 20 workmen during 10 days yielded:—A-1 quality, 7,888 carats; 1st quality, small, 7,540 carats; and 2nd quality, large, 10,440 carats; the total value being close on £300. The deposits have as yet been only superficially opened up, and a long life to these mines is anticipated.

Chrysoberyl.

Platy crystals of this mineral have been found in the corundum-bearing felspar-veins near Kangayam in the Coimbatore district, associated with nepheline syenites; but the crystals are too highly flawed to be suitable for gems. Yellow crystals, transparent and of good quality, are said to occur with mica and aquamarine in pegmatite veins at Govindsagar, Kishangarh State, Rajputana.

[1] *Rec. Geol. Sur. Ind.*, Vol. XLIX, pp. 161—172.

Garnet.

The only garnets worked to any considerable extent in India occur in the mica-schists of Rajmahal in Jaipur State, at Shahpura in Udaipur State, in the Sarwar district of Kishangarh State, and in the district of Ajmer-Merwara, all these localities being within a relatively small distance of each other. Returns are not available to show the condition of the industry in the Jaipur State, but the statistics obtained indicate the existence of a considerable industry in the other areas. (See table 125.)

These returns, such as they are, indicate a large decrease in the output of Ajmer-Merwara and of Shahpura, and an increase in the output of the Kishangarh State in 1914. The Kishangarh garnets are stated to be the finest in India.

The garnets being worked in India belong to the almandite variety, and have a purple colour. Stones of large size are obtained and their cutting for the market forms an important industry in Jaipur and Delhi. Garnets of small size but rich colour are very plentiful in the sands of the Travancore coast.

Garnets are also found in other parts of India, as in the Tinnevelly district, Madras,[1] which produced about 1,000 tons of garnet sand for abrasive purposes in 1914. The workings both in Tinnevelly and in Kishangarh were closed down the following year. Attention may also be drawn to the fact that the manganese garnet, spessartite, so characteristic of the gonditic rocks of the Central Provinces, is in America sometimes used as a gem. The Indian variety varies from a beautiful bright orange to red-brown, but has not yet been found sufficiently free from flaws to be of use as a gem.[2]

Iolite.

Cordierite or iolite, a mineral exhibiting striking pleochroism, is found in the gem gravels of Ceylon, and cut as a gem under the name of lynx-sapphire and water-sapphire. A polished and roughly engraved piece of iolite found in some excavations at Budh Gaya, and showing strong pleochroism, deep violet to nearly colourless, has long been in the Indian Museum, but no locality for the mineral was known.[3] It has now been found at two localities, namely, in complex rocks composed of sillimanite, hypersthene and biotite, in the Vizaga-

[1] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 234 (1906).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 604 (1909).
[3] V. Ball, *Proc. As Soc. Beng.*, 1881 p. 89.

Table 125.—*Production of Garnet in India during the years 1914 to 1916.*

	1914.		1915.		1916.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Cwts.	£	Cwts.	£	Cwts	£
Ajmer-Merwara . .	1·8	*9*	1·4	*10*	...	...
Kishangarh (Sarwar) .	464	*4,333*	...	...	...	...
Hyderabad . .	...	...	113·8	(*a*)	395	(*a*)
Madras (Tinnevelly) .	21,440	*464*	...	...	...	...
Mysore (Kolar) . .	...	...	...	...	80	(*a*)
TOTAL .	21,905·8	*4,806*	115·2	*10*	475	(*a*)

(*a*) Not available.

patam Hill-tracts,[1] and in the Kadavur Zemindari, Trichinopoly district, Madras, where Mr. P. N. Bose reports its occurrence in abundance near Udaiyapatti and Kiranur, associated with labradorite and mica-schist. There are ancient pits, dug apparently for this mineral.

Kyanite.

Kyanite is found at many localities in the Archæan formations of India and is occasionally used as a gem-stone on account of the fine blue colour it sometimes displays.[2] An authenticated locality for gem kyanite is Narnaul, Patiala State. The jewellers at Patiala call it *bruj*, and say that it sells at Rs. 3 to Rs. 5 per tola, equivalent to 10*s*. to 16*s*. 8*d*. per ounce.[3] Kyanite is also plentiful in Kanaur and Bashahr in the Punjab Himalayas,[4] where it has often been mistaken for sapphire.

[1] T. L. Walker, *Rec. Geol. Surv. Ind.*, XXXVI, p. 13 (1908).
[2] M. Bauer and L. J. Spencer, 'Precious Stones,' p. 415 (1904).
[3] P. N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59 (1906).
[4] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 102 (1904).

Rhodonite.

Rhodonite, a manganese-pyroxene, is used abroad (*e.g.*, in the Urals) as a gem and cut into all kinds of ornamental objects. It is found at many localities in India associated with manganese-ore deposits; and although none of it has yet been used for ornamental purposes, suitable material for the manufacture of small objects could be obtained at several of the mines.[1]

Tourmaline.

The beautiful red tourmaline, known as rubellite, is worked on a small scale in the Ruby Mines District of Upper Burma. The production during the four years 1904 to 1907 averaged 101 lbs. valued at £750. Since then no figures have been received.

An interesting report was published in 1908 by Mr. E. C. S. George, Deputy Commissioner of the district,[2] on the workings for tourmaline round the small Palaung hamlet of Sanka about a mile east of Maingnin, where operations were carried on by the Chinese, according to local tradition, some 150 or 200 years ago. Mr. George states that after the Chinese deserted the area, the Kachins re-opened the mines about forty years ago, but the industry was again interrupted until about 1885, when more systematic operations were commenced under Pu Seinda, who contracted to conduct all mining operations until 1895. The Möng-mit (Momeit) stone-tract was afterwards notified by Government and regular licenses were taken up in 1899. During the years 1903 to 1905 the amounts recovered from 'tourmaline licenses,' the rate being Rs. 2 per worker per month, were Rs. 2,000 (£133) to Rs. 3,000 (£200) each year; since then they must have fallen off.

The tourmaline is found in soft, decomposed granite-veins, which, being generally covered by a thick deposit of jungle-clad soil, are found rather by accident than through the guidance of any superficial indications. Isolated crystals are found occasionally lying in the red soil, and men with small means sometimes find it profitable, when they have leisure, to search through the soil-cap by digging shallow pits. *Twinlons* or vertical shafts, about 4 to 5 feet square are also put down on the chance of striking a tourmaline-bearing vein, or *kyaw*, and the owners of these *twinlons* are permitted to extend their workings underground to a radius of five fathoms from the centre of each shaft. Some of the workings extend to depths

[1] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, pp. 144, 604 (1909).
[2] *Rec. Geol. Surv. Ind.*, XXXVI, pp. 233—238.

of about 100 feet, which appears to be about the limit of the miners' engineering skill. The tourmaline found is sorted into three classes: (1) *ahtet yay*, the best light-pink rubellite, of which there are two kinds, *hteik ti*, showing well-developed basal planes, and *be yan*, crystals terminated by rhombohedral faces, or with only a small development of the basal plane; (2) *akka*, of a darker colour, with the lower part of the crystals brown or black in colour; (3) *sinzi* or *arnyi*, all fragmentary crystals of any colour which are imperfect, or of a small size, less than about an inch. The *sinzi* is given without charge to the buyer of the lots of the two better kinds. The best kind, *ahtet yay*, may bring as much as Rs. 1,200 to Rs. 1,500 a viss (3·65 lbs.). The *myaw* system, or exposure of the veins on the hill-side by hydraulic action, has also been attempted at two localities with uncertain results: this work is limited to the Rains and is handicapped by the cost of leading the water-channels for long distances. All locally made purchases are effected by brokers, usually Shans or Shan Burmans. They in turn sell at Mandalay to purchasers for the Chinese market.

In 1909, 7 stones weighing 63·8 *ratis* or 37·5 carat,[1] valued at £26, were found in the Northern Shan States.

A beautiful green tourmaline with a crystalline limestone matrix is worked in a small way at Namon near the Salween river in the Southern Shan States. Green and blue varieties occur in the pegmatites of some parts of the mica-mining area of the Hazaribagh district, but the stones are not worth the cost of extraction.

Green tourmalines are also found at the Sapphire Mines area of Zanskar in Kashmir.

Zircon.

The mineral zircon is known in various parts of India, and where it occurs in the nepheline-syenite series near Kangayam in the Coimbatore district, it is picked up in small quantities and passed into the market as corundum; but it is nowhere found sufficiently transparent and flawless to be used as a gem. Similar material is met with in Travancore (see page 309).

Glass-making Materials.

[H. H. HAYDEN.]

The common, impure sands of the rivers and the efflorescent alkali salts, so common in many parts of India, are used in various

[1] At 1 *rati* = $1\frac{7}{8}$ grains troy = ·592 carat.

places for the manufacture of the inferior varieties of glass used for bangles.

For a long time the chief difficulty in the way of manufacturing the better grades of glass in India was the absence of known deposits of quartz-sand of the requisite purity and of suitable texture. In recent years, however, sand of great purity has been obtained from the Vindhyan sandstones at Loghra and Borgarh near Naini in the United Provinces, and from Cretaceous and Tertiary sandstones found at Pedhamli and Sankheda in Baroda State[1]; specimens of these sands have been examined by Professor P. G. H. Boswell, who has reported very favourably on them; the Naini material was found to contain 98·95 per cent. SiO_2,[2] and a Baroda specimen as much as 99·39 per cent. A very pure sandstone is also found in Bikaner State. Glass-works using local sands or sandstones have been established in many parts of India, amongst which may be mentioned Allahabad, Ambala, Jubbulpore and Madras. Bombay works, however, import their sand from Naini, a distance of over 900 miles. Other materials required in large quantities, such as fire-clay, fire-bricks, coal, are to be had in various parts of India, but soda is found only in small quantities in the Central Provinces and Sind; the efflorescence known as *reh* contains a variable amount of sodium carbonate, but no experiments have yet been made to ascertain to what extent its extraction might be practicable; for the present soda must be imported.

The restriction of imports during the war gave a remarkable impetus to the Indian glass-making industry, and by the end of the war there were about twenty factories at work. Most of these will probably find it difficult to carry on when the import trade in European glass is resumed, and greater attention must in future be paid to economic factors which have hitherto been largely disregarded. At present there are works operating which bring practically all their raw materials hundreds of miles by rail, their sand perhaps nine hundred miles, their fire-clay and fire-bricks seven hundred and their coal at least five hundred. It is difficult to see how enterprises established on such lines can hope to compete against imported glass, and until the question has been more care-

[1] V. S. Sambasiva Iyer: Sketch of the Mineral Resources of Baroda (1910).

[2] British Resources of Sands and Rocks used in glass-making (1918). In the footnote on page 157 it is stated that Jubbulpore sand is used in the Allahabad glass-works; there is some slight confusion here, as the Allahabad works use the Loghra and Borgaru (Naini) sand, which is quarried more than 200 miles from Jubbulpore.

fully studied in its technical and its commercial aspects, little progress is likely to result.[1]

Gypsum.

[E. H. PASCOE.]

Gypsum occurs in considerable abundance in various parts of India, occurring both in the fibrous form and as clear selenite crystals. In Baluchistan, the Tertiary clays and shales of all ages, whenever they are but slightly disturbed, contain numerous crystals of gypsum scattered throughout their mass[2]; in Sind it occurs in beds sometimes 3 to 4 feet thick near the top of the Gaj beds of the Khirthar range; in Cutch it occurs in abundance in the rocks below the Nummulitic limestones; in the Salt Range it occurs in large masses with the salt marl, underneath Cambrian beds; along the foot of the Kala Chitta range in the Rawalpindi and Attock districts, it is characteristic of the Upper nummulitic stage, reaching thicknesses of two or three feet locally. This mineral is especially characteristic of the Lower Tertiary.

A very interesting and, judging of the returns, comparatively important occurrence is N.N.W. of Nagaur in Jodhpur (Marwar), Rajputana, where a bed, 5 feet thick or more, occurs in silt probably formed in an old salt-lake. The output from the Nagaur district during the five years 1914 to 1918 is shown in table 126.

Selenite crystals of similar origin to that of Nagaur have been recently found in the kankar near the base of the silt in the Sambhar lake, and are also obtained at Pachbadra during the manufacture of salt from brine.[3] A small gypsum deposit of no economic value occurs in the Chamba Valley, Dholpur State.[4] There is also a considerable production of gypsum at Jaunsar in Bikanir, Rajputana (see table 126).

New occurrences of gypsum have been discovered in the Vindhyan series at Satna in Rewah State[5] (probably of no economic value); in the Kangra Chhu in Bhutan,[6] in association with dolo-

[1] This matter has been ably dealt with by Sir Alfred Chatterton in his note on "The Manufacture of Glass in India," published in the *Industrial Handbook* (Indian Munitions Board), 1919.

[2] E. Vredenburg, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 209 (1909).

[3] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXII, p. 231 (1905).

[4] A. M. Heron, *Rec. Geol. Surv. Ind.*, XLIV, p. 20 (1914).

[5] L. L. Fermor, *Rec. Geol. Surv. Ind.*, XXXIII, p. 233 (1906).

[6] G. E. Pilgrim, *Rec. Geol. Surv. Ind.*, XXXIV, p. 28 (1906).

Table 126.—*Production of Gypsum in India during 1914 to 1918.*

	1914.		1915		1916.		1917.		1918.		Average.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Punjab (Jhelum) . . .	2,620	*65*	773	*39*	615	*31*	1,068	*53*	1,871	*93*	1,389	*56*
Rajputana (Bikanir) . .	15,503	*679*	16,816	*730*	11,613	*520*	8,116	*661*	8,469	*772*	12,103	*672*
Rajputana (Marwar) . .	4,145	*235*	4,974	*210*	3,800	*194*	7,499	*320*	6,406	*274*	5,365	*247*
Total .	**22,268**	*979*	**22,563**	*979*	**16,028**	*745*	**16,683**	*1,034*	**16,746**	*1,139*	**18,857**	*975*

mites; in the Hamirpur district, United Provinces,[1] in limited quantities in the Older Alluvium, and under similar circumstances in the adjoining parts of the Jhansi district,[2] where it is called *usraith.* Gypsum is also found in Spiti and Kanaur, in the Punjab Himalayas. Between the Lipak and Yuland rivers in Kanaur the gypsum occurs in immense masses and thick beds replacing Carboniferous limestone; it is used locally for whitewash, but the inaccessibility of the deposits would render abortive any attempt to mine the mineral for transmission to the Indian markets.[3]

Marble.[4]

[E. H. Pascoe.]

Occurrence.

India has long been famous for its marbles, chiefly on account of the fine buildings, such as the Taj Mahal, built from this material by the Moghals. The best known occurrences of white marble are at Makrana in Jodhpur, at Kharwa in Ajmer, Maundla in Jaipur, Dadikar in Alwar, and at Tonkra in Kishangarh, the last-named being dolomitic marble. It is to the coarseness of their grain that these marbles owe in part their resistance to the weather; it is their purity that enables them to maintain their white surface, and it is their translucence that gives them their delicate softness, which could never be obtained from a fine-grained marble more suitable for statuary than for architectural purposes. Similar white marble occurs in unlimited quantities forming the hills of Kyaukse, Sagyin, and Mandalay, on the banks of the Irrawadi. A coarse white marble is found in Mergui; whilst a saccharoidal dolomitic marble is exposed in large quantities at the far-famed Marble Rocks, forming a beautiful gorge traversed by the Narbada river near Jubbulpore. 143 tons of marble valued at £237 have been reported from the Betul district in the Central Provinces.

Homogeneous yellow marble, and also yellow and grey shell marble, is found at Jaisalmer in Rajputana. Serpentinous limestones, showing green and yellow tints, are found in Ajmer and

[1] T. D. LaTouche, *Rec. Geol. Surv. Ind.*, XXXVII, pp. 281—285 (1909).
[2] C. A. Silberrad, *Rec. Geol. Surv. Ind.*, XLII, p. 56 (1912).
[3] H. H. Hayden, *Mem. Geol. Surv. Ind.*, XXXVI, p. 101 (1904).
[4] T. H. Holland, *Journal of the Queen Victoria Indian Memorial Fund*, No. II, March 1904, pp. 18—26. *See also* General Report for 1913, *Rec. Geol. Surv. Ind.*, XLIV, p. 16 (1914).

other places along the Aravalli belt; but the most striking example of this class occurs at Motipura in the Baroda State in the form of a handsome mottled green marble; a beautiful marble is obtained also at Sandara. A black marble taking a good polish, and other varieties, are found in Rewa Kantha, Rajpipla. Near the Narbada River in the Indore State a fine coralline limestone, capable of a high polish, is quarried, and used in the construction of temples and palaces. Very variegated serpentinous limestones occur also in parts of the Cuddapah and Karnul formations in the Madras Presidency, and at several localities in the Nagpur and Chhindwara districts in the Central Provinces. Marble is plentiful in the Idar State. Pink marbles occur in abundance in the Aravalli belt of Rajputana, and in the Narsinghpur district of the Central Provinces. Mottled and streaked grey marbles occur in Jodhpur; dark-grey marbles are obtainable in Kishangarh and Jodhpur, while black marble has been found at Bhainslana in Jaipur. A mottled concretionary dolomitic marble occurs in the Vindhyan series in the Gwalior State, whilst onyx marbles are found at Nurpur in the Shahpur district, and near Jhuli in the Baluchistan desert.

Victoria Memorial.

Extensive tests made in the Laboratory of the Geological Survey on the Makrana marble[1] have shown that it is superior in many respects to the foreign marbles imported from Greece and Italy, and it was therefore decided to employ it in the construction of the Victoria Memorial in Calcutta. Messrs. Martin & Co., contractors for the building, have therefore opened up quarries at Makrana and have erected derricks for bringing the stones to the surface, as well as an extensive plant for cutting and dressing the stone. Considerable difficulty was experienced at first in getting the required quantity of suitable material, but this has now been overcome and a large supply of marble of great beauty is being made available. With the exception of European supervision the work at the quarries is done entirely by indigenous labour and the local artisans have now been trained to turn out carving of a high degree of excellence. Messrs. Martin & Co.'s operations at Makrana were not in a sufficiently advanced stage to have any appreciable effect on the output during the previous quinquennium, but the period under review has witnessed a steady output averaging 3,500 tons a year. This marble has been quarried for centuries.

[1] *Rec. Geol. Surv. Ind.*, Vol. XLVI, pp. 276—279.

Marble is also quarried at the State Marble Works about 8 miles from Narnaul Railway Station, Patiala State, where an experimental marble plant has been installed. There is also a small annual output of marble in the Mandalay district for images and pillars, but no figures of production are available.

Imports.

In spite, however, of the existence of such large supplies of marbles of every variety in different parts of the Indian Empire, there is a large import of marble from abroad, chiefly from Italy and Greece. This is due partly to the great distances that separate the Indian marble deposits from such cities as Calcutta and Bombay, and partly to the systematic organisation of quarrying operations in Europe, by which the cost of foreign marble has been reduced. The foreign imports of stone and marble during the five years 1914 to 1918 averaged 8,662 tons a year, valued at £28,734. On account of the freight advantages attaching to the supply of European marbles, it would probably not pay to lay out much capital on Indian marble quarries; but, with an order sufficiently large to warrant systematic quarrying operations, marble ought to be procurable at a cost that would repay employment in Rajputana, and possibly in Burma. The Rajputana quarries are both protected and hampered by their distance from the sea-board, but in Burma there are hills of marble standing on the banks of the Irrawadi, and therefore well suited for water transport.

TABLE 127.—*Production of Marble in Jodhpur, Rajputana, during the years 1914 to 1918.*

YEAR.	Quantity.	*Value.*
	Tons.	£
1914	3,044	*2,230*
1915	3,735	*3,047*
1916	3,814	*2,131*
1917	3,032	*3,182*
1918	3,896	*2,250*
Average	3,504	*2,568*

Mineral Paints.

[H. H. HAYDEN.]

Up to the present the manufacture of mineral paints appears to be very small in proportion to the demand and the natural resources in minerals apparently suitable. In the Jubbulpore district the soft hematites of Jauli have been worked for red ochre, and yellow ochre has been worked in Panna State.

The war gave a considerable impetus to indigenous paints, and works were also set up in Mysore. There was a small output of ochre in Bihar and Orissa.

Such figures as are available are summarized in table 128, in which the values are mostly much understated, being usually the rental or royalty paid. The Central Indian production is derived mainly from Panna, Baraunda, Gwalior, and Sohawal, and that of the Central Provinces from red-ochre pits in the Gangai zamindari, Drug district.

Ochres, red, yellow, and of other colours, are commonly used by Indians in many parts of the country, in a crude or simply levigated form, under the generic name *geru*. A common source of supply is laterite in the Peninsula and Burma, but well-defined ochres occur in deposits of various geological ages down to the Archæan hematites. In the Trichinopoly district yellow ochre is obtained from the Cretaceous rocks, and in Burma deposits are known among the Tertiary beds of the Myingyan district. It is also probable that various grades of ochre, umber, and sienna could be set aside from the 'country' when working the Vizagapatam manganese-ore deposits. A black slate near Kishangarh has been successfully tried on the Rajputana-Malwa Railway. Barytes, an ingredient of many mineral paints, is obtainable in quantity in the Madras Presidency and elsewhere (see *Barytes*) and some manufacturers have their own quarries.

Mineral Waters.

[E. H. PASCOE.]

One curious feature in connection with Indian minerals is the neglect of our numerous hot and mineral springs. To what extent the value of these is purely fanciful is a matter of small concern for the time being; for whether they have the medicinal properties

TABLE 128.—*Production of Ochre in India during 1914 to 1918.*

	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa	..	..	..	..	3·5	*1*	69	*49*	145	*639*	43	(b)*138*
Central India	500	*150*	463·5	*458*	839	*541*	2,174	*772*	7,874	*2,192*	2,370	*823*
Central Provinces	108	*7*	12	*1*	8	*1*	900	*808*	16	(a)	209	*162*
Mysore	..	..	..	..	..	..	..	..	74	*59*	15	(b) *12*
TOTAL	608	*157*	475·5	*459*	850·5	*543*	3,143	*1,629*	8,109	*2,890*	2,637	*1,135*

(a) Valued at Rs. 5 only. (b) Average of 5 years.

claimed for them or not, there is no doubt that well-advertised mineral waters have an economic value, and numerous varieties from Europe and Japan are scattered over India, and brought to the continual notice of the travelling public in all the railway refreshment rooms. Natives of India have for many ages recognised a value in mineral waters and in the hot springs, which are often charged with more than usual quantities of mineral matter. In many cases these, like most unusual natural phenomena, have become sacred to the Hindus, and have consequently become places of resort for pilgrims from great distances. Of instances of this sort may be mentioned the hot springs at Manikarn in Kulu where the pilgrims cook their rice in the hot springs emerging in the shingle beds close to the ice-cold stream of the Parbati river. The hot water is also led into the neighbouring temple and rest-house for baths, being supposed to be of value for rheumatism. At Lasundra in the Kaira district, and at Vajrabai in the Thana district, Bombay Presidency, springs of sulphurous water, having a temperature of 115° F., are also resorted to by Hindu pilgrims. Generally it may be said that hot springs, often sulphurous, are common throughout the Tertiary areas of Sind and Baluchistan on one side, and of Assam and Burma on the other side of India, the distribution being similar (and perhaps dependent on similar causes) to the distribution of petroleum, with its constant associates of salt and gypsum. Other springs occur along the foot-hills of the Himalaya, in the Kharakhpur hills, etc., sufficiently well distributed to permit of easy transport. The springs at Jawalamukhi in the Kangra district contain bromide and iodide of sodium and potassium; the water is said to be a remedy for goitre. The provincial gazetteers contain sufficient references to these springs to guide private enterprise, but more might be done in the way of analysis of the waters, which would be as interesting from a scientific as possibly from an economic point of view. The mineral water of Sitakund in the Kharakhpur hills is the only one which has been turned to account; this has some reputation in Bengal as a table water. An investigation into the radio-activity of the thermal springs of the Bombay and Madras Presidencies was recently undertaken by the Reverend Dr. A. Steichen and the Reverend H. Sierp, of St. Xavier's College, Bombay. The results of these two observers were published in two papers in the Indian Medical Gazette, Vols. XLVI and XLVII (December 1911 and December 1912).

The springs at Tuwa on the line from Cambay to Godhra (Panch Mahals) were found to possess unusually high radio-active properties. Comparatively large emanations were found at Vajrabai and Unei also. The authors express the opinion that more should be made of the therapeutic properties of these and other radium-containing springs.

Nickel.

[E. H. PASCOE.]

Ores of nickel (nickeliferous pyrrhotite) have been found amongst the copper-ores of Khetri and other places in Rajputana. Nickel has also been detected in small quantities in chalcopyrite and pyrrhotite found associated with the gold-quartz reefs of Kolar, and in pyrite said to be from the Henzada district of Burma. Complex sulphide ores, consisting of pyrrhotite, pyrite, chalcopyrite, and molybdenite, have been received from the Tovala taluk in South Travancore. Both nickel and cobalt are present in quantities beyond mere traces, but nothing is yet known as to the extent of the deposits, nor have any proper average samples been assayed. A surface sample of ore showed 1·20 per cent. of copper, 0·64 per cent. of nickel, and 0·08 per cent. of cobalt, with 12 grains per ton of gold and 2 dwts. 12 grs. per ton of silver. Further investigations may show that the deposits are richer than is indicated by this analysis.

There is a considerable consumption of nickel in India in the form of German-silver, the annual imports of which during the five years 1914 to 1918 have averaged 239 tons worth £28,177 (see page 13). Further, on the 1st August 1907, the issue to the public was commenced of the new 1-anna nickel coinage, consisting of an alloy of 25 parts of nickel with 75 of copper, leading to a further consumption of nickel, statistics for which are not available.

The imports of nickel received at the Bombay Mint between the years 1914-15 and 1918-19 totalled 169 tons, 2 cwt. valued at Rs. 4,94,152; none was imported in 1915-16.

Phosphates.

[H. H. HAYDEN.]

A regrettable feature in connection with Indian mineral resources is the absence, in a country where agriculture is such a predominant

industry, of any phosphatic deposits of proved value, and a further circumstance to be regretted is the export of phosphates in the form of bones. Bone meal and other animal manures are now manufactured to a certain extent in Calcutta, but until a supply of cheap sulphuric acid is available superphosphate cannot be made and the small quantity used is imported from Europe. During the past five years the value of the materials imported under the head of manures has fallen from £69,468 in 1913-14 to £826 in 1918-19, the average annual value being £35,227 ; this, of course, is the direct result of the war. For a similar reason the exports of bones fell from 64,000 tons in 1914-15 to 17,000 tons in 1918-19 ; exports of all manures, including ammonium sulphate, also fell in quantity but rose greatly in value, from 74,000 tons valued at about £378,000 in 1914-15 to 47,000 tons valued at £411,000 in 1918-19.

TABLE 129.—*Exports of Manures from India during the years 1914-15 to 1918-19.*

—	TOTAL MANURES.		ANIMAL BONES.	
	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£
1914-15	74,602	*377,785*	63,975	*319,553*
1915-16	60,178	*295,777*	50,636	*235,583*
1916-17	61,668	*374,983*	42,042	*216,277*
1917-18	40,449	*315,884*	21,842	*109,381*
1918-19	46,578	*410,881*	16,734	*84,409*
Average	56,695	*355,062*	39,046	*193,041*

Phosphatic nodules of Trichinopoly.

Among the phosphatic deposits of India only two seem to merit attention, the phosphatic nodules of Southern India and the apatite-magnetite rock of Singhbhum. The first of these is the deposit of septarian nodules occurring in the Cretaceous beds of Perambalur

taluk, Trichinopoly district. Dr. H. Warth estimated in 1893 that to a depth of 200 feet the beds contained nodules to the amount of 8 million tons, but the phosphates are distributed irregularly through clay, the quantity varying, in the different excavations made, between 27 and 47 lbs. per 100 cubic feet, and, in the shallow workings, 70 lbs. per 100 cubic feet. Analyses of these nodules show them to contain from 56 to 59 per cent. of phosphate of lime with about 16 per cent. of carbonate. The sparse distribution of the nodules and their high calcium carbonate content are unfavourable to the commercial success of any attempt to manufacture superphosphate. Attempts have been made to use the material in a finely powdered condition as a fertilizer, but the results have not been encouraging.

Magnetite-apatite deposits, Singhbhum.

The existence of apatite-magnetite rocks at Patharghara and Musaboni in Dhalbhum has been known for some years, and deposits have been located along a belt stretching for 12 miles in a direction S. 37° E. from Patharghara to Khejurdari, and included in concessions secured by the Bengal Iron and Steel Company, Limited, for iron-ore, and by the Great India Phosphates, Limited, for apatite. The magnetite-apatite rock occurs as lenses in the Dharwar schists parallel to the strike, and varying in size from 90 feet long by 24 feet thick in the middle, through lenses 2 feet or 3 feet by 1 foot down to lenticles a few inches long, and then to separate granules and crystals disseminated in the associated schists. As a rule apatite is the predominant mineral.[1] The amount of phosphate rock available has not yet been determined while experiments made on the crushed rock with a magnetic separator did not prove successful and work was suspended; the Great India Phosphates Company has since gone into liquidation.

Rare Minerals.

[G. H. Tipper.]

Additions continue to be made to the number of minerals of the so-called rare earths, the new discoveries being chiefly from the pegmatites of peninsular India. None of those referred to below, with the possible exception of molybdenite in Tavoy, are known to occur in quantities sufficient to justify extensive exploitation.

Molybdenite, the sulphide of molybdenum, occurs in Tavoy as—

(*a*) an accessory mineral in the granite,

[1] *Rec. Geol. Surv. Ind.*, L, p. 14.

(*b*) in greisens bordering cassiterite and wolfram veins,
(*c*) in quartz veins with cassiterite and wolfram,
(*d*) in pegmatites with wolfram, cassiterite and sometimes scheelite,
(*e*) in veins with sulphides and entire exclusion of cassiterite and wolfram.

The mineral is widely distributed but of more frequent occurrence in or about veins in granite than in those enclosed by sedimentary rocks. It is especially abundant in the Wagon region Kyaukanya and at Sonsin which furnishes the only known occurrence of type (*e*). No attempts have been made, in spite of the high value of the mineral, to recover it by scientific processes, and, owing to its flakiness, it is not recoverable by the primitive processes of "cobbing and panning" so prevalent in the field. The small quantities which have been exported were obtained by laboriously picking out the larger flakes by hand from the quartz matrix. The Sonsin deposit is the most promising known at present but it is little more than a "prospect."

Molybdenite was one of the first minerals to form in the Tavoy veins and is often found intergrown with mica on the walls.

Molybdenite occurs in the crystalline rocks and in quartz in various parts of Chota Nagpur. It has been found as scattered scales in pegmatites intruded into the Khondalite series near Kunaveram village in the Upper Godavari Agency, Madras. A similar mode of occurrence has also been noticed in the aplite and pegmatite veins traversing the schistose gneisses 1½ miles east of Karadikuttam in Retiambadi Mitta, west of Palni, Madura district, Madras. It occurs in an elæolite-sodalite-cancrinite pegmatite at Mandaoria, near Kishangarh, Rajputana, and has been found in a pegmatite cut through at a depth of 2,500 feet in the Balaghat lode, Ooregum, Kolar Gold Field, Mysore. Molybdenite occurs disseminated through the pyrrhotites of the Travancore State.

From Tavoy an output of 39 cwts. valued at £897 was reported during the period 1916-18.

Platinum and Iridosmine.—Platinum and Iridosmine have been found in the auriferous gravels of the rivers draining the slopes of the Patkoi ranges, both on the Burma and the Assam sides. The former metal used to be obtained, with gold, by the Burma Gold Dredging Company from the gravels of the Irrawadi above Myitkyina. This Company went into liquidation in 1918 and since

that time no platinum has been produced in India. The output from 1914 amounted to a little over 67 ounces valued at £378.

Columbite-Tantalite.—There is a perfect gradation from columbite (niobate of iron and manganese) to tantalite (tantalate of the same elements) due to the gradual replacement of niobium (or columbium) by tantalum. This change is accompanied by a corresponding increase in specific gravity, the range being from 5·3 to 7·3. There is at present no commercial use for niobium (columbium). Tantalum is, however, used in the preparation of metallic filaments for lamps and consequently tantalite is of much greater value than columbite, the value depending on the percentage of tantalic oxide in the mineral.

Although at any locality where one of these minerals occurs, the presence of the other may reasonably be expected, tantalite is a very rare mineral. Columbite is frequently found in the mica-bearing pegmatites. It is not uncommon in the Singar Zamindari, Gaya district, where near the village of Pichhli beautiful crystals have been obtained[1]; in the Kodarma forest, Hazaribagh district and Monghyr (Pananoa Hill) in the Province of Bihar and Orissa; in the Madras Presidency in the Madura, Nellore, Salem and Trichinopoly districts; at Masti[2] in the Bangalore district and other places in the Mysore State[3]; in Kashmir, near Machial, 20 miles from the Padar Sapphire Mines.

Tantalite occurs with columbite at Pananoa Hill near Jhajha Railway Station, East Indian Railway. Two specimens sent to the Geological Survey Office have the high specific gravities of 6·75 and 6·92; assays have shown 37 and 52 per cent. of $Ta_2\ O_5$ respectively.

Ilmenite, titaniferous iron ore, occurs as a common accessory mineral in many of the crystalline rocks of peninsular India. It is occasionally found in masses of some size in the mica pegmatites of Bihar and Orissa. It accompanies wolfram at Degana in Rajputana. It is found in abundance in the beach sands of Travancore and in concentrates from Tavoy and other parts of Burma. About 3 miles south of Kishangarh in Rajputana large crystals of ilmenite, 2-3 inches in diameter, are found associated with clear calcite crystals forming a broad vein in the granitoid gneiss. This ore was at one time smelted in the local native furnaces.

[1] G. H. Tipper, *Rec. Geol. Surv. Ind.*, L, pp. 260 and 261 (1919).
[2] L. L. Fermor, *Mem. Geol. Surv. Ind.*, XXXVII, p. 204.
[3] Mineral Resources of Mysore, p. 192.

Rutile, one of the natural forms of titanic oxide, is widely distributed throughout many of the crystalline schists. It has been found in pieces of some size during exploratory work for mica in the neighbourhood of Ghatasher in the Narnaul district of Patiala State, Punjab.[1] Mr. Bose also reports the occurrence of this mineral in the vicinity of Kadavur in the Trichinopoly district of Madras.

Sphene, titanite and silicate of calcium, is a not uncommon accessory mineral in many of the crystalline rocks. A large and beautiful crystal of a variety containing a noticeable percentage of cerium earths was obtained by Dr. A. M. Heron in Rajputana, but its exact provenance is unknown.

Pitchblende.—Pitchblende or uraninite with other uranium minerals has been found at two localities in the Singar Zamindari, Gaya district, Bihar and Orissa. The occurrence at Abraki Pahar near the village of Bhanen Kap has been known for some years.[2] The chief mineral associated with the pitchblende here is triplite, a phosphate of iron and manganese, in considerable quantities. Columbite and zircon also occur. The locality was visited by the late Mr. R. C. Burton who found that the pitchblende occurs as nodules in the pegmatite, each nodule having an aureole of yellow uranium ochre.[3] A company was formed for the exploitation of this occurrence but it was liquidated in 1914. The prospecting work done did not show the presence of any large deposit. The second locality is near the village of Pichhli where the pitchblende is found in a pegmatite in a similar way to the above. The associated minerals are monazite, apatite and columbite.[4]

Green and yellow incrustations containing uranium occur on the apatite-magnetite rock at Sungri, Dhalbhum, Bihar and Orissa.

Samarskite.—The very rare mineral samarskite has been found in a mica-bearing pegmatite near Gridalur village, Nellore district, Madras.[5] Altogether 44½ cwts. were won during the period under review. Samarskite is a very complex niobate and tantalate, chiefly of uranium, the yttrium earths, and iron.

Some pieces of a black mineral supposed to be samarskite have been found in pegmatites in the Bangalore district, Mysore State. A small piece has recently been received from Tavoy.

P. N. Bose, *Rec. Geol. Surv. Ind.*, XXXIII, p. 59 (1906).
T. H. Holland, *Mem. Geol. Surv. Ind.*, XXXIV, p. 31 (1901).
R. C. Burton, *Rec. Geol. Surv. Ind.*, XLIV, p. 31 (1914).
G. H. Tipper, *Rec. Geol. Surv. Ind.*, L, pp. 259—261 (1919).
G. H. Tipper, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 342 (1910).

Sipylite, a niobate of erbium and other rare earths occurs in association with samarskite. It has also been found in a mica pegmatite about 3 miles to the north-west of Sankara, Nellore district.

Hatchettolite, a tantalo-niobate of uranium, has been identified from the Tovala taluq, Travancore. Associated with this is found a closely allied mineral, as yet unidentified. A specimen similar to the latter has been discovered in a pegmatite 5 miles west of Vaiyampatti, Kadavur Zamindari, Trichinopoly district, Madras.

Æschynite, a titano-niobate of the cerium earths, has been identified from a pegmatite in the Eraniel taluq, Travancore State.

Gadolinite, a silicate of yttrium, beryllium and iron, has been found in a tourmaline pegmatite, associated with cassiterite, in the Palanpur State, Bombay Presidency.

Allanite, a hydrous silicate of calcium, aluminium, iron and the rare earths, has been found in some of the pegmatites of the Nellore district (Sankara, Vadlapudi and Turpupundla) and near Palni, Madura district, Madras. In Bihar and Orissa it occurs near Bahea village, in the Ranchi district.

Zircon, orthosilicate of zirconium, is a common accessory mineral in many granites and gneisses, and as such it is often found accompanying gravels and sands derived from such rocks. It is a constant constituent of the beach sands of Travancore. Fine crystals are to be obtained from some of the pegmatites of the Travancore State. Zircon is found in the nepheline syenites near Kangayam, Coimbatore district; in pegmatites at Kadavur, Trichinopoly district; and in the Seitur graphite mine, Ramnad, Madras Presidency. Large clusters of crystals of a dark brown colour have been obtained from Abraki Pahar, Gaya district, Bihar and Orissa. A hydrated form resembling cyrtolite containing a small percentage of uranium is associated with samarskite in the Nellore district, Madras.

A mineral related to *Xenotime*, orthophosphate of the yttrium earths, has recently been noticed in long rhombic prisms associated with the phosphate deposit at Kanyaluka in Dhalbhum.

Thorianite ?—A black mineral doubtfully identified with thorianite has been discovered at Thadagay Hill, Travancore. The mineral is apparently isometric. The specific gravity is extremely high, 10·03. Owing to the paucity of material a partial analysis only could be made, and this gave as the principal constituents, thoria 32·3 per cent. and uranium oxide 40 per cent. The identity

with thorianite is very doubtful and it might easily be a variety of uraninite. More is required to be known of this interesting find.

Slate.

[E. H. PASCOE.]

Slate-quarrying gives a means of livelihood to numbers of workers along the outer Himalayas, where the foliated rocks, though often not true clay-slates, possess an even and perfect fissility, which enables them to be split for slabs and even fine roofing slates at Kanyara. In the Kangra district, work is being carried on in a systematic manner by the Kangra Valley Slate Company, Limited, which during the five years ending the 31st December 1918 has declared dividends of 22 per cent. per annum. The same Company works quarries in clay-slates amongst the Aravalli series near Rewari in the Gurgaon district south of Delhi. Another company working in the Kangra district is the Bhargava Slate Company.

In the Kharakhpur Hills, Monghyr district, Bihar, the properties held by Messrs. C. T. Ambler & Co. were transferred to a limited company, Ambler's Slate and Stone Company, in 1913. This company in the year 1918-19 employed 250 persons daily on an average, and raised 1,821 tons of slate, valued at Rs. 28,164. The slate worked is often slightly phyllitic and is probably of Dharwarian age. Though not giving the thinnest varieties of roofing slate these quarries produce fine slabs for which a more extended use is continually being found for flooring, roofing, ceilings, and for small dishes and curry platters for native use. Enamelled slate slabs for electrical purposes, switch-boards and fuse-bases are also manufactured. Recently a new branch of the business has been opened for the manufacture of school slates, and an average of 22,000 framed slates is being produced monthly. Some of the quarries held by this company date back to ancient times, and probably yielded the very fine piece of slate from which the throne of the Nawabs Nazim of Bengal, now shown in the Indian Museum, was fashioned.

Slate of good quality and in considerable quantity was observed in the valley of the Tuzu River, some 25 miles east of Kohima, in the Naga Hills.[2] The locality is just within the borders of our administered territory, but is somewhat remote for present-day

[1] T. H. Holland, *Rec. Geol. Surv. Ind.*, XXXI, p. 43 (1903).
[2] E. H. Pascoe, *Rec. Geol. Surv. Ind.*, XLII, p. 263.

TABLE 130.—*Production of Slate during 1914 to 1918.*

—	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa—												
Monghyr (*d*)	2,600	*2,907*	2,700	*3,000*	2,136	*2,197*	1,900	*1,833*	1,821	*1,878*	2,231	*2,363*
Singhbhum	..	..	100	*67*	100	*67*	100	*67*	..	..	60	*40*
Hyderabad	(*a*)	*1,428*	(*a*)	*1,341*	(*b*)	Not reported	(*b*)	*2,797*	(*b*)	Not reported	(*c*)	(*c*)
Punjab—												
Gurgaon	2,830	*2,200*	1,995	*1,394*	1,361	*891*	1,314	*1,325*	2,170	*2,145*	1,934	*1,591*
Gurdaspur (*e*)	61	*107*	13	..	69	*1*	75	*2*	6	..	45	*22*
Kangra (*e*)	6,940	*5,563*	5,902	*5,934*	5,778	*6,285*	5,442	*6,471*	5,938	*6,977*	6,000	*6,246*
United Provinces—												
Almora	1,240	*729*	1,043	*385*	49,350	*321*	43,025	*546*	27,676	*358*	24,467	*467*
Naini Tal	..	..	1	..	3	*1*	..	..	..	..	(*c*)	(*c*)
TOTAL	13,671	*12,934*	11,754	*12,121*	58,797	*9,763*	51,856	*13,041*	37,611	*11,352*	34,737	*10,729*

(*a*) Weights not available.
(*b*) The output during the years 1916, 1917 and 1918 was 1,075,031 sq. ft., 187,162 sq. ft., 2,792,302 sq. ft. respectively.
(*c*) Not taken into average.
(*d*) Output by Ambler's Slate and Stone Co., Ltd.
(*e*) Output by the Kangra Valley Slate Co., Ltd.

exploitation. It is used by the half-civilised local tribes for roofing, millstones and other purposes.

Slate is also being worked in various parts of the so-called transition series of rocks of the Peninsula; such figures as are available to show the extent of the trade are given in table 130 with the figures of production of the two companies already mentioned. The figures returned by the Nizam's Government, Hyderabad, show the annual production of a substance returned as 'slabstone'; but whether this 'slabstone' is slate or not is not known. The output of the United Provinces is derived from the Almora and Garhwal districts. Except in Gurgaon, there has been a general increase in production over that of the previous five years, showing that the commodity is coming more and more into use.

Sodium Compounds.

[G. de P. COTTER.]

Besides sodium chloride, other salts of soda, notably the sulphate (*khari*) and carbonate (*sajji*), accumulate in the soil of areas where the climate is dry, giving rise to the alkaline efflorescence known as *reh*, which renders large areas quite sterile. Both the sulphate and carbonate are also prominent amongst the sodic compounds in the brine of the Rajputana Salt Lakes. Carbonate of soda occurs in quantity in the water of the Lonar Lake referred to below.

Imports.

There was formerly a considerable production of both salts for consumption in India, but the native material is now being displaced by the cheap supplies of chemically manufactured material obtained from Europe. The total imports of soda salts have increased very rapidly during the past decade; in 1905 they were estimated at £70,000, in 1913 at £212,649, and in 1918 at £651,885. The imports of sodium bicarbonate during the quinquennial period averaged 114,462 cwts., valued at £52,619, whilst the imports of caustic soda averaged 78,303 cwts., valued at £108,682. The annual total imports of soda salts averaged 805,776 cwts., valued at £494,635. A large deposit of sodium carbonate is being worked by the Magadi Company in East Africa as it is proposed to purify this raw material at Budge-Budge near Calcutta.[1]

[1] Indian Munitions Board Handbook, 1919, p. 70.

For information concerning the alkali compounds used and manufactured in India, reference may be made to the *Agricultural Ledger*, No. 5 of 1902, published by the Reporter on Economic Products, Calcutta. Other numbers of the Ledger give information about *reh*. Those interested in *reh* lands should also consult Dr. J. W. Leather's 'Investigations on Usar Land,' Allahabad (1914).

Sodium sulphate.

Sulphate of soda or *khari* is obtained by the lixiviation under licenses from the Northern India Salt Revenue Department of saline earths in the alluvial tracts of Bihar, the producing districts being Saran, Champaran, and Mozaffarpur. The two former districts yielded a total average annual production for the five years 1913-14 to 1917-18 of 6,161 tons valued at £16,638. The details are shown in table 131. The figures for the Mozaffarpur district show an annual average production of 11,578 tons of *khari* valued at £8,341.

TABLE 131.—*Production of Sulphate of Soda in Bihar and Orissa during 1913-14 to 1918-19.*

YEAR.	CHAMPARAN.		MOZAFFARPUR.		SARAN.		TOTAL.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£
1913-14	2,244	*6,060*	11,934	*9,017*	4,164	*11,245*	18,342	*26,322*
1914-15	1,468	*3,965*	10,323	*7,800*	2,338	*6,315*	14,129	*18,080*
1915-16	1,648	*4,450*	9,169	*6,920*	3,003	*8,110*	13.820	*19,480*
1916-17	2,053	*5.545*	12,401	*9,369*	5,381	*14,530*	19,835	*29,444*
1917-18	2,211	*5,970*	14,062	*8,600*	6,296	*17,000*	22,569	*31,570*
Average	*1,925*	*5,198*	*11,578*	*8,341*	*4,236*	*11,440*	*17,739*	*24,979*

Lonar Lake.

The proposal to utilise the incumulations of soda salts in the Lonar Lake (19° 59′ : 76° 33′) in the Buldana district, Berar, has been frequently raised, but the place is too inaccessible at present for anything like development on a large commercial scale. This lake was investigated by Mr. T. H. D. LaTouche and Dr. W. A. K. Christie in 1910.[1] The

[1] *Rec. Geol. Surv. Ind.*, XLI, pp. 266—285 (1912).

lake lies in a depression in the Deccan Trap, and its origin, though not satisfactorily explained, has been regarded as probably similar to that of the so-called 'explosion craters' of the kind described by Mr. R. D. Oldham in the Lower Chindwin district.[1] Mr. LaTouche, however, regards it as due to the collapse of a gigantic blister caused by vapour or molten rock. The depression is nearly circular, about a mile in diameter and 300 feet deep; at the bottom there is a shallow lake of saline water, which is variable in density and quantity according to the season of the year. The most prominent salts in solution are the carbonate and chloride of sodium, the former being in excess and often found separated on account of supersaturation, when it takes the mineralogical form of *trona* or *urao*, $Na_2CO_3NaHCO_32H_2O$. A series of analyses by F. J. Plymen of the various crystallised products indicate the presence of the following percentage proportions of soda salts (a small portion of the soda being replaced by potash) :—

—	Bhuski.	Papri.	Khappal.	Dalla.	Dalla Nimak.	Nimak Dalla.
Na_2CO_3 . .	32·72	23·19	24·09	46·90	33·05	11·67
$NaHCO_3$ . .	27·53	17·21	18·18	33·18	26·09	8·58
NaCl . .	3·35	41·99	37·45	...	24·25	71·11

In each case the ratio of carbonates is very close to that required for the urao formula, and sufficient water for crystallisation is also present. Dr. Christie calculated that in March 1910 the brine contained about 2,000 metric tons of alkali reckoned as sodium carbonate and that the superficial 1·5 metres of mud (with an alkalinity equivalent to 0·26 per cent. of sodium carbonate) contained some 4,500 tons of sodium carbonates. In the absence of borings the depth to which such mud persists is unknown. The presence of the sodium carbonate in the lake water is regarded as due to concentration by evaporation of stream waters in the absence of an exit from the lake, whilst the chloride is regarded as in part windborne from the sea-coast.

[1] *Rec. Geol. Surv. Ind.*, XXXIV, p. 137 (1906)

Considerable quantities of soda salts were recovered from this lake in the old days for use in the manufacture of soap and glass; but, since the principal markets for soda are now served by the cheaper and purer products of the European chemical manufacturer, there is little demand for the impure salts from Lonar. Suggestions are offered for improving the methods of manufacture, but even under the most favourable conditions the industry could never become an important one, owing to the limited resources of the lake.

The total output of soda salts from Lonar during the quinquennium 1909-13 was estimated to be 446½ tons valued at £1,115, but from 1914 to 1918 no salt was extracted. The contract fell vacant in March 1914 and remained so till the middle of 1916, when the Pioneer Alkali Works Company of Bombay took it up. This company has so far been unable to make use of their concession owing to the influx of a large quantity of water and consequent dilution of the salt water; the quantity of salts now in the lake is reported to be scarcely one per cent. Attempts have been made, but not with complete success, to stop the advent of fresh water into the lake.

Sind.

Although statistics are not available further back than 1895, Sind has yielded annually small quantities of natural soda from a remote past. The trade in alkali is mentioned by H. Pottinger writing in 1816, and is noted in the first edition of the Sind Gazetteer (1874). The product, which is trona, either in pure form, or associated with chloride and sulphate, is known as *chaniho* or *kharo chaniho*, and is both used locally and exported from Karachi.

The soda is collected during the hot weather, at the periods of maximum evaporation, from the alkaline lakes (*dhands*) of eastern Sind. These alkaline *dhands* are found exclusively in that portion which is covered with wind-blown sand, and may be classed in two geographical groups:—

(1) The Nara group, lying in a belt of country about 20 miles broad by 50 miles long, bisected by the East Nara Canal. The greater part of this belt lies in Khairpur State, but a southward extension penetrates the Nawabshah district, and the Sanghar *taluqa* of Thar and Parkar.

(2) The Jubo group, situated entirely in Khairpur, and lying to the east of Kot Jubo in the eastern part of the State.

These *dhands* were examined in 1918-19 and a report upon them will shortly be published in the Memoirs of the Geological Survey.

The *dhands* are situated in depressions (*talis*) usually of an oval shape between the sand-hills (*bhits*), and are produced owing to the accumulation of percolating (*sim*) water flowing from the basal layer of the desert sand, the water being prevented from sinking further by the highly impervious alluvial clays which everywhere in the Sind desert underlie the wind-blown sand. This percolating or *sim* water carries into the *dhands* the soluble salts of the buried soil. These salts are similar in composition to the *reh* or *kalar* salts of N.W. India, and consist of carbonate, bicarbonate, sulphate, and chloride of sodium with subordinate amounts of potash salts. In the Sind desert within the limits of the alkaline areas, the carbonate and bicarbonate as a rule are preponderant, although some highly saline, and one or two sulphatic *dhands* occur.

The *dhands* may be classified as (1) *dhands* which deposit or have in former years deposited *chaniho* owing to solar evaporation and deposition in the hot weather, and (2) *dhands* which owing either to depth of water or to insufficient concentration of dissolved salts have never deposited *chaniho*. In the Khairpur State there exists a total of 94 *dhands* of the first category, 48 being situated in the Nara, and 46 in the Jubo area. These *dhands* produce *chaniho* only in favourable years, those which contain much water only producing in dry years, and those with scanty water remaining dry during the whole annual round in dry years, but producing in wet years. Some of the *dhands* are probably permanently dry owing to secular desiccation, and will never produce again. Of the 94 *dhands* listed, 30 produced *chaniho* in 1918, 40 were dry, and 24 had excessive water.

The second category consists mainly of large *dhands*, some of which are rich in alkali, and might possibly be worked for soda on a commercial basis. Thirty-three *dhands* of this class have been recorded in the Khairpur State.

In the Nawabshah district only three *dhands* produced *chaniho* in 1918: only one *dhand*—Akanwari—is of any importance. Besides this there are two large alkaline *dhands* which have never yielded. The Thar and Parkar district has not yielded *chaniho* since 1899, in which year the worked *dhands* became exhausted of their stock of alkali, and deposited a largely saline residue.

The waters of the two largest alkaline non-producing *dhands* in the Khairpur State have the following analysis :—

Name of Dhand.	CO_3	SO_4	Cl	Total dissolved solids.	Sp. Gr.
Pur Chandar . . .	19·75	2·73	17·57	79·88	1·070
Khariri Chachwari . .	20·68	14·57	20·59	103·4	1·089

Note.—The figures represent grammes per litre.

In most of the *dhands*, the deposit is trona with a purity of 90 per cent. or over. In some, such as Lambro, Chilhanwari, Bagarwaro, the deposit is contaminated with a large intermixture of sulphate; a few *dhands* such as Barko, although yielding a fairly pure alkaline deposit, are deficient in their stock of bicarbonate, and therefore yield normal carbonate largely (a dehydrated natron).

The following are the total amounts of *chaniho* produced in Sind during 1915-16 and 1916-17 :—

YEAR.	Khairpur State.	Nawabshah.	Total production in Sind.
	Mds.	Mds.	Mds.
1915-16	33,147	10,215	43,362
1916-17	21,213	4,775	25,988

In the Haidarabad bazar, the prices in 1919 varied from Rs. 14 for the best quality to Rs. 4 for the lowest grade per maund.

On the shores of the *dhands* the price per maund varies from Re. 1 to Rs. 1-14 per maund.

The greater portion is exported, mainly to Bombay and Basra, the export figures being :—

YEAR.	Quantity.
	Mds.
1915-16	19,760
1916-17	23,964

Steatite.

[E. H. PASCOE.]

One of the most widely distributed minerals in India is steatite, either in the form of a coarse potstone—so called on account of its general use in making pots, dishes, etc.—or in the more compact form suitable for carvings, and in its best form, suitable for the manufacture of gas-burners. Cooking utensils of steatite are much in request by high-caste Hindus, since they can be purified after use by fire and communicate no unpleasant taste to food. There is a trade of undetermined extent in nearly every province, but it is in most cases impossible to form even a rough estimate of its value. An exhaustive account of the Indian occurrences of steatite was published by Mr. F. R. Mallet in the *Records, Geological Survey of India*, Vol. XXII, part 2 (1889); and a later note[1] adds further details with regard to the deposits in the Minbu district, Burma. In 1911-12, Mr. C. S. Middlemiss[2] discovered a large deposit of steatite of very fair quality near Dev Mori in Idar State, Bombay Presidency, associated with various other magnesian minerals (actinolite, magnesite, serpentine, asbestos). He estimates that bed of steatite to be over 1 mile long with a width of over 200 feet and a vertical dip. On this basis it is calculated that 2 million tons are obtainable in the first 20 feet from the surface. Dr. A. M. Heron has collected notes on some hitherto undescribed steatite deposits in Jaipur State, Rajputana.[3] The principal localities are:—Dogetha, 2½ miles N.E. of Raialo; Gisgarh, and Morra. In the last-mentioned area one of the beds measures 25 feet in thickness, and pockets of steatite extend over a distance of 5 miles.

Such figures as are available for the output of Indian steatite are summarised in table 132. The values assigned to the mineral vary between very wide limits, and although this is no doubt partly due to differences in the value of the product according to the use to which it is put, yet some of the figures are probably but rough estimates.

The steatite deposits on the north side of the Marble Rocks in the Jubbulpore district, according to Dr. Fermor, form pockets in the dolomite of the gorge. They were formerly worked by

[1] H. H. Hayden, *Rec. Geol. Surv. Ind*, XXIX, p. 71 (1896).
[2] *Rec. Geol. Surv. Ind.*, XLII, p. 52 (1912).
[3] *Rec. Geol. Surv. Ind.*, XLIII, p. 21 (1913).

TABLE 132.—*Production of Steatite during the years 1914-18.*

	1914.		1915.		1916.		1917.		1918.		AVERAGE.	
	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*	Quantity.	*Value.*
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Bihar and Orissa— Singhbhum . . .	(*a*)	*400*	(*a*)	*333*	(*a*)	*250*	..	..	..	..	..	*(b)197*
Mayurbhanj . . .	60	*173*	50	*133*	52	*333*	50	*267*	40	*233*	50·4	*228*
Central India— Bijawar	..	..	..	..	..	..	73·3	*386*	..	..	14·7	*(b)77*
Central Provinces— Jubbulpore . . .	502	*429*	329	*336*	891·75	*794*	2,421·8	*2,619*	3,492·8	*4,069*	1,527·5	*1,649*
Madras— Bellary	25	*17*	28	*19*	36	*12*	23	*8*	44·5	*15*	31·3	*14*
Karnul	210	*1,576*	..	..	10·45	*116*	10·3	*115*	10·1	*110*	48·2	*(b)383*
Nellore	60	*715*	45·7	*407*	50·5	*251*	19·5	*77*	51	*218*	45·3	*334*
Salem	..	..	529·4	*720*	87	*325*	149·6	*762*	642·8	*909*	281·8	*(b)543*
Mysore	..	..	..	..	..	..	8·5	*17*	·1	..	1·7	*(b)3*
Rajputana— Ajmer-Merwara . .	..	..	..	..	..	..	119·7	*319*	..	..	23·9	*(b)64*
United Provinces— Hamirpur . . .	120	*744*	95	*630*	76	*504*	80	*630*	247	*2,111*	123·4	*924*
Jhansi	22	*92*	..	..	10	*43*	11	*48*	10	*43*	10·6	*(b)45*
TOTAL .	999	*4,146*	1,077·1	*2,578*	1,213·7	*2,628*	2,966·7	*5,248*	4,538·3	*7,708*	2,158·8	*4,461*

(*a*) Quantity not returned.

(*b*) Average of 5 years.

native methods with a small annual production, but have now been taken up on mining lease by Messrs. P. C. Dutt and Burn & Co.; the latter have erected a grinding mill in their pottery works at Jubbulpore and are converting their steatite into powder, whilst deposits at Gowari and Lalpur on the south side of the Narbada have been secured by the Bombay Mining and Prospecting Syndicate. The annual output from this area during the period averages 1,527 tons valued at £1,649, more than three times what it was during the previous five years.

The Burmese production shown in the previous quinquennial period came from the Minbu, Pakokku Hill Tracts and Myitkyina districts, and was used for pencils. The mines in the Minbu district have been described by Dr. Hayden[1] and are situated some 30 miles west of Hpa-aing. The veins of the mineral are very inconstant and ramify through dark green serpentine, expanding occasionally to 8 or 9 inches across. The colour is green and the quality good. The absence of any figure for production in the last quinquennium is said to be due partly to the gradual replacement of the steatite pencil by pen and paper, and partly to the exhaustion of the deposits.

During the previous quinquennium, Mr. A. Ghose continued to open up the steatite deposits at Muddavaram and Musila Cheruvu near Betamcherla in the Karnul district, taking out a mining lease in 1912. A market was obtained in America and on 158 tons exported in 1913, the prices obtained ranged from £7 for 'nugget' steatite to £14 per ton for block steatite, c.i.f. New York or European ports, most of the output of this year being white steatite from Musila Cheruvu. The larger portion of the steatite of this locality is green, and has fetched a price of £10 a ton. At Muddavaram the steatite is ivory white associated with quartzose rock and magnesite and is suitable for small articles, such as gas-burners. The output in 1914, however, fell to 210 tons, in 1915 to *nil* and in 1916, 1917 and 1918 to just over 10 tons each year.

Sulphur, Sulphuric Acid and Soluble Sulphates.

[H. H. HAYDEN.]

Sulphur.

Small quantities of sulphur are obtainable on the dying volcano of Barren Island in the Bay of Bengal, in the state of Kelat in Eastern Baluchistan, and on

[1] *Rec. Geol. Surv. Ind.*, XXIX, pp. 71-76.

the Koh-i-Sultan, and neighbouring volcanoes in Seistan and Eastern Persia. The Kelat sulphur mine near Sanni, which was formerly worked to some extent, has recently been examined and the available sulphur estimated at 10,000 tons[1]; this is a conservative estimate, but even if the actual amount is several times greater, the deposit cannot be regarded as of serious potential value, since it represents little more than a year's supply.

India is likely therefore to be dependent for her acid on by-products from the reduction of metallic sulphides, and a scheme is already on foot for the erection of a plant at Sakchi to treat the zinc concentrates of Bawdwin. Its annual capacity at first will probably be not more than 30,000 tons, but a cheap supply of acid would be the key to many industries which would find a ready market for their products, and there is no doubt that in a few years' time a very much larger output would be readily absorbed. The absence of such industries has been seriously felt during the war. Thus the average annual value of imported bleaching materials alone during the five years 1914-18 has been £88,709; for this import, formerly brought from Europe, India has recently been dependent on Japan, and complaint has been made of the quality of some of the manufactured articles supplied by that country. With a local supply of acid this would not have occurred, and it is to be hoped that the next few years will see a great advance towards making India self-contained in the matter of the more essential chemical manufactures.

A considerable amount of acid is already manufactured in India, but the industry is dependent entirely on imported sulphur. This used formerly to come from Sicily, but latterly it has been possible to import only Japanese sulphur.

During the five years, 1914 to 1918, the imports of sulphur have averaged 156,022 cwts. a year, valued at £74,137, as compared with an annual average of 102,601 cwts. valued at £32,991 for the period of the previous review. The average annual import of sulphuric acid was 7,918 cwts. valued at £7,639, as compared with 63,769 cwts. valued at £39,087 for the period of the preceding review.

Sulphate of iron and copper.

For many years pyritous deposits in India have been turned to account for the manufacture of soluble sulphates of iron and copper. The case of alum has been referred to already (*supra*, page 250),

[1] G. de P. Cotter, *Rec. Geol. Surv. Ind.*, L, p 137 1919).

and with the alum, which was formerly obtained in quantity from the decomposed pyritous shales at Khetri and Singhana in Rajputana, copperas and blue vitriol were also obtained. No statistics are, however, available with regard to the history of these industries, which have had to give way to the importation of cheap chemicals from Europe.

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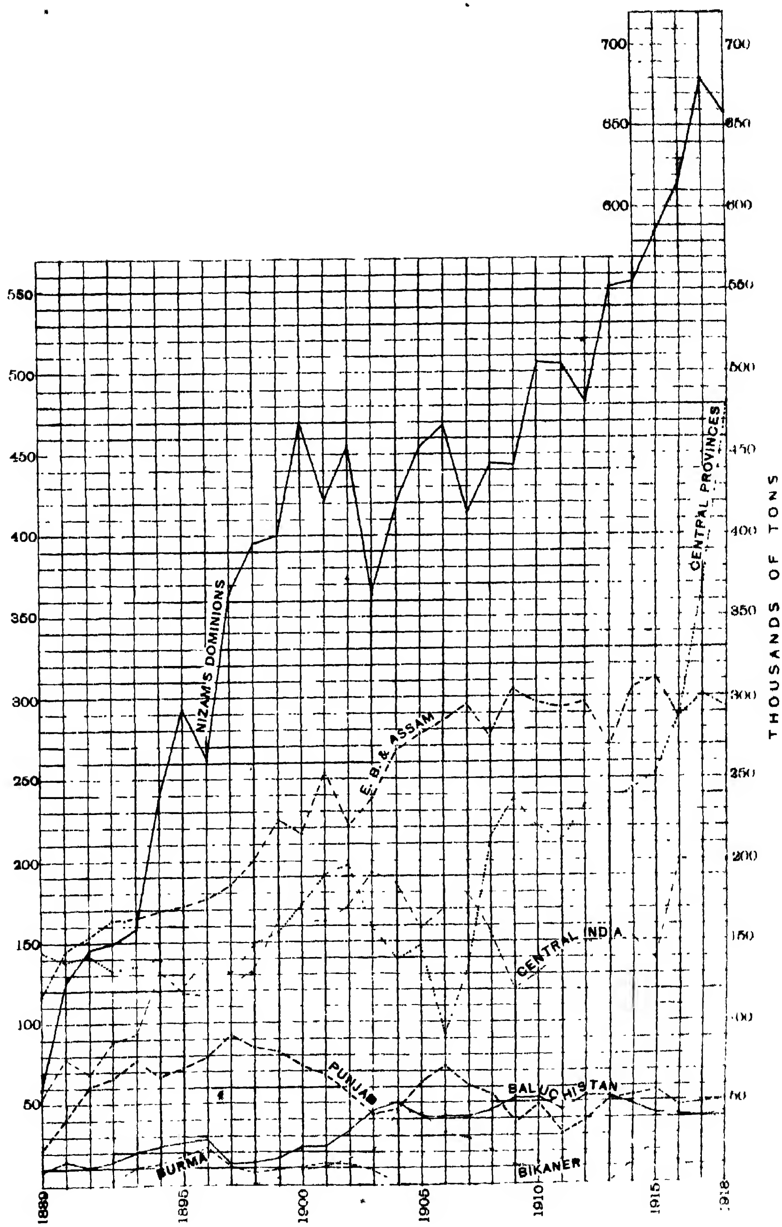

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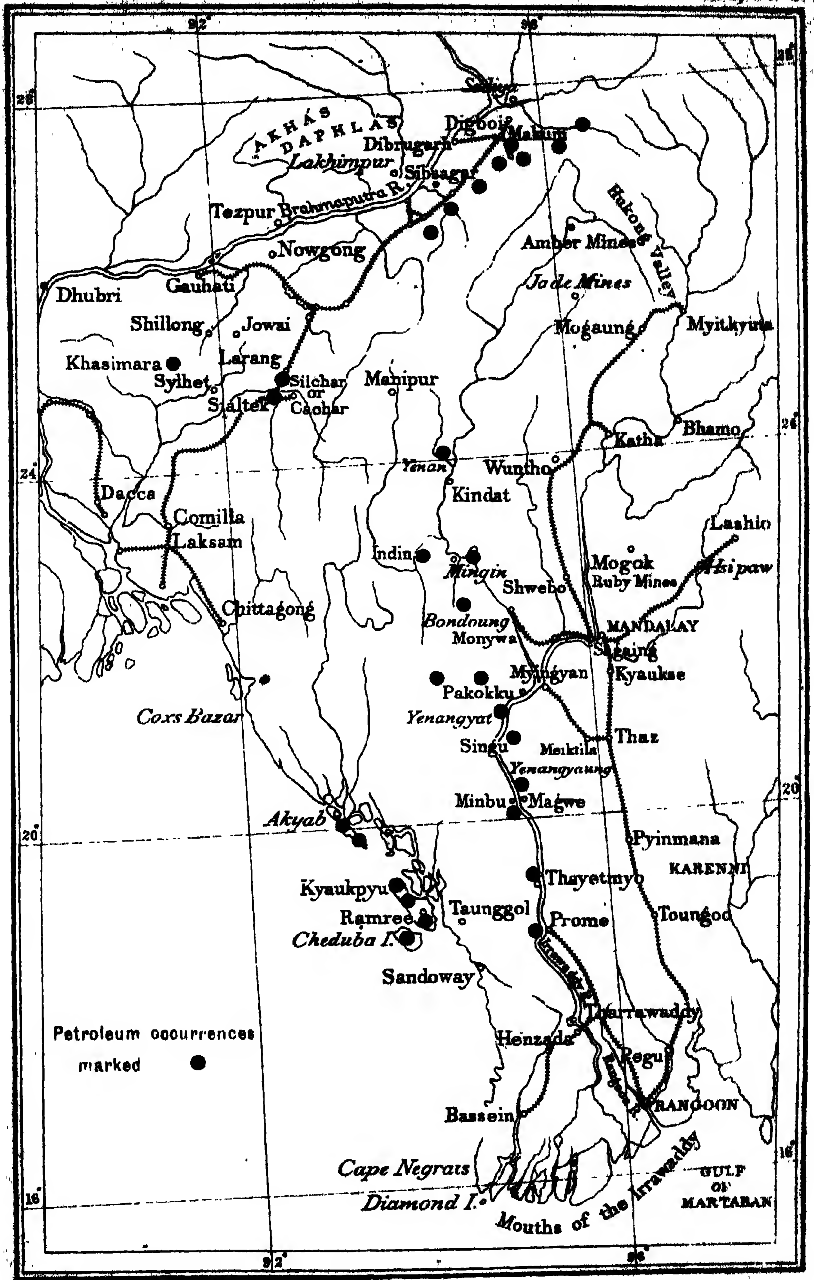
PROVINCIAL OUTPUT OF COAL FOR THE YEARS 1889—1918



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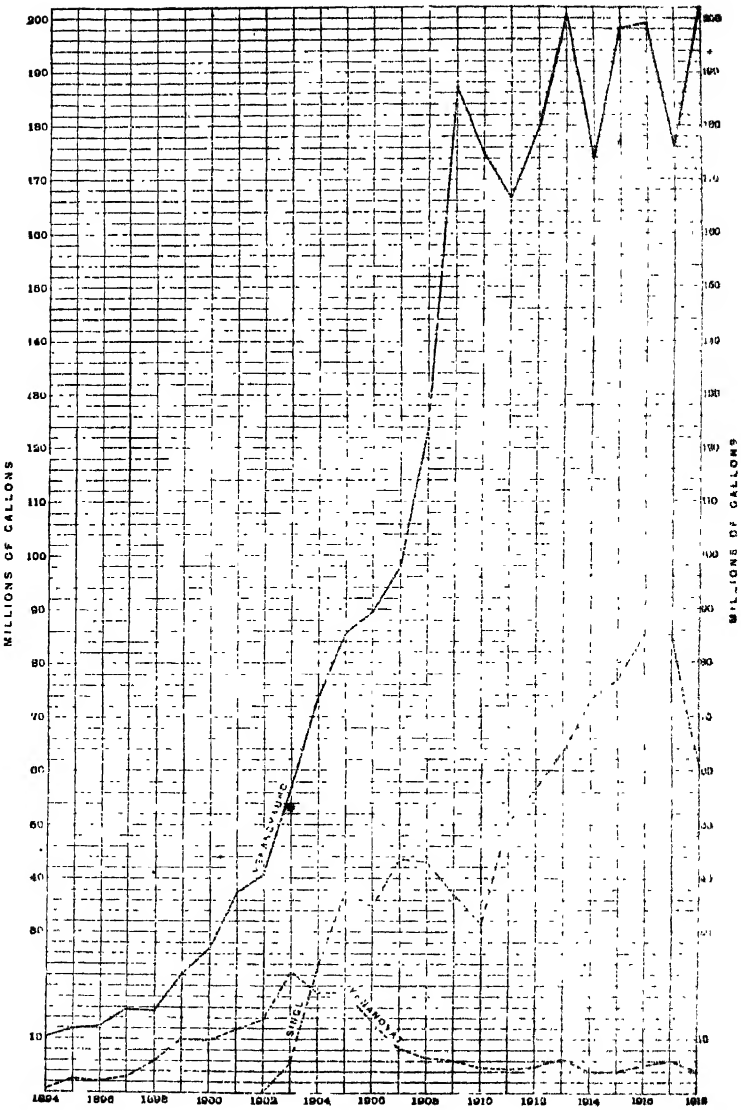
OCCURRENCES OF PETROLEUM IN ASSAM AND BURMA.

(Scale 1 = 128 miles.)

Records, Vol. LII, Pl. 6.



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PRODUCTION OF UPPER BURMA OIL-FIELDS.